manufactured by the Michigan Alkali Co., at Ford City and used largely in the production of soap.

Rock salt. In a swamp bordering Detroit River, south of the River Ecorse, the first unsuccessful attempt was made in 1902 to sink a shaft for the mining of rock salt. The failure, however, was a success in that it presented the first serious problem, and suggested its solution. A square hole, 24 feet x 24 feet, was first dug to a depth of about 14 feet, passing through 4 feet of fresh muck, 2 feet of mucky clay and 4 to 6 feet of a mottled (yellow, brown and blue) lake, or river clay, carrying shells, but no pebbles. Then followed about 70 feet of soft, bluish-drab till, with some few pebbles, cobbles and boulders, the only break being at 30 feet where a 6 to 8-inch stratum of gravel, or gravelly clay, was encountered. A drop casing of brick, cylindrical in form, 15 feet in diameter and one foot thick was constructed and provided with a steel shoe. This was allowed to settle as the excavation proceeded and was added to at the top. At a depth of about 55 feet a great amount of "creep" was experienced, 48 hours' progress amounting to but 1½ feet, instead of about 14 feet. When within a short distance of the rock, at a depth of some 80 feet, the casing showed signs of weakening under the strain caused by the *creep* of the clay and, although an effort was made to strengthen it, the entire structure collapsed and the hole filled with water.

The second attempt to get at the solid salt has proven successful but only by the most determined effort and highest engineering skill. Reaching the solid rock, its removal proved comparatively simple, but the suffocating gases and floods of water encountered would have literally swamped and discouraged most companies. That the enterprise was brought to successful completion is due to the rare skill and judgment of the engineer in charge, Eugene F. Bradt and his corps of efficient helpers. The work was begun Dec. 12, 1904, by the "Detroit Salt Mining and Manufacturing Co.," capitalized at $500,000, and was intended to include later the Detroit Salt Co. and the River Rouge Salt Co. The site of the shaft is in Oakwood, a small Detroit suburb, just south of the Rouge about ½ mile and two miles from Detroit River. The elevation of the mouth of the shaft, as determined by W. C. Cooper, is 575.2 ft., above sea level. A drop shaft of timber was constructed, 6 ft. x 16 ft. in the clear (8 ft. x 18 ft. outside) with a cutting edge, protected by a sheet of steel. As the digging was carried on below the casing was allowed to settle and was built on above, passing through 73 feet of soft, blue clay (Wisconsin till) and 10 feet of sand and clay mixed, reaching bedrock (Dundee limestone) at

83 feet, or an actual elevation above sea level of 492 feet. This limestone was entered 17 feet, early in July, 1905, but was so strong in hydrogen sulphide gas (H_2S) that work was suspended until the 20th of November. The eyes of the men were painfully affected and some of the workmen were overcome. At one stage of the work, firemen's helmets were used, supplied with fresh air through rubber hose, but were found cumbersome and were then discarded. The almost imperceptible structural break between the Dundee and the Monroe came at about 146 feet and then followed the succession of strata making up the various divisions of the Monroe formation, as indicated in the section given on Fig. 21. Below 100 feet the casing was reduced to 5 ft. 4 in. x 15 ft. 4 in., inside measurements, the shaft being cased with 2 in. planking and 12 in. framing timbers.[5] The last week of June, 1909, the work extending over a period of 4½ years, an 8-foot stratum of salt was reached at a depth of 878 feet. With no water or gas now to cause trouble, it was simply a matter of time to reach the heavier deposits of purer salt, and, by the close of the year, a depth of 1042 feet had been reached, entering a 20-foot vein of salt which is the one now being worked by means of "drifts," (1040 to 1060 feet). The average monthly progress made was 17⅔ feet, the greatest record being made in the dolomite, April, 1909 (672 to 765 feet), amounting to 93 feet. This was accomplished by offering the men a bonus for all that was accomplished beyond a certain amount.

Six noteworthy water horizons were encountered as the work progressed as follows:

1. Depth 83 ft.; elevation 493 ft. Just over rock with a temperature of 52.2°F. (Cooper).

2. Depth 86 to 88 ft.; elevation 489 to 487 ft. Dundee limestone, quite heavy flow and rank in hydrogen sulphide gas.

3. Depth 135 ft.; elevation 440 ft. Dundee limestone, small flow.

4. Depth 155 to 168 ft.; elevation 420 to 407 ft. Lucas dolomite, porous. Flow continuing down to 181 ft., or elevation 394 ft. Sulphurous. Temperature at 180 ft. was 49.5° F. (Cooper).

5. Depth 191 ft.; elevation 384 ft. Remarkably heavy flow from a horizontal opening extending across the shaft. Lucas dolomite. Water strong in sulphur and under a pressure of 90 lbs. per square inch, causing the shaft to fill in 3 to 4 hours.

6. Depth 420 ft. to 533 ft.; elevation 155 ft. to 42 ft. above sea level. Seepage flow of sulphur water throughout Sylvania sandstone, except for a 27-foot stratum of dry, silicious dolomite (Sylvania dolomite).

5. A detailed description of the shaft from an engineering standpoint will be found in the Engineering and Mining Journal, March 18, 1911, p. 565. "Shaft of the Detroit Salt Company" by Albert H. Fay.

Mr. Bradt estimated the total flow above the base of the Sylvania as 2,000,000 gallons a minute, this being reduced to not over 500 gallons by the use of Portland cement forced into the fissures of the rock under a pressure of 1200 lbs. to the square inch. The vein at the depth of 191 feet required several carloads of cement before the flow could be controlled, and the services of a diver to insert the pipe at the proper point. Preparatory to blasting, holes were drilled obliquely about the margin of the shaft, one foot apart, and into these were forced all the cement slush that they would receive. In the case of the Sylvania, a concrete lining, 24 to 30 inches thick was required to restrain the flow. Below the Sylvania, the flow was greatly reduced and finally completely disappeared. The shaft was ventilated during the progress of the work by a canvas flue, in 50-foot lengths, and 4½ feet in diameter, through which air was forced to the workmen.

The shaft is to be divided into three compartments, separated by board linings, two for the operation of the 2½-ton skips and the third provided with a set of ladders for emergency purposes. A series of 10-inch holes is being drilled alongside the shaft to receive the steam and water pipes, electric wiring, etc. The surface equipment consists of a boiler house, hoisting plant, and a coal crushing, steel head frame 125 feet in height (see Pl. XXXII, B). Six grades of salt are secured by crushing and screening; as follows:

Lumps. Coarse fragments for salting stock.

No. 2. Passes through ⅜ inch mesh and caught on ¼ inch mesh screen.

No. 1. Passes ¼ inch mesh and caught up on 3-16 inch mesh.

"C.C." Coarse chemical. Passes 3-16 inch mesh and caught upon ⅛ inch mesh.

"F.C." Fine chemical. Passes ⅛ inch mesh and caught upon 1-16 inch mesh.

"Dust." Everything passing through 1-16 inch mesh.

The plant is located alongside a branch of the Michigan Central Ry. and the company has constructed a line—"The Detroit and Western Ry." from its shaft house to the Wabash, slightly over a half mile to the west. The markets for the salt thus far are mainly Chicago and St. Louis, the salt being used mainly in curing fish, meat and hides, manufacture of ice cream and general re-

frigeration. Henceforth, the mining of rock salt is to be reckoned as one of Michigan's important industries, the only other states producing this material being New York, Kansas, Louisiana, Utah, Idaho and California.

Pigments. Deposits of red and yellow ochre, of sufficient size to be of economic importance, occur in Sumpter township. These represent swamp deposits of iron oxide, transported through the agency of plants and finally precipitated along with impurities of sand and alumina. Iron bearing minerals contained in the soil furnished the original supply, the decay of which led to the formation of iron oxide, which in the presence of the carbon dioxide gas, resulting from plant decay, was converted into the very soluble iron sulphate ($FeSO_4$) or the iron carbonate ($FeCO_3$), which is somewhat soluble, especially in water containing the carbon dioxide gas. In these forms, the iron may be transported to the swamp, where upon standing the carbonate or sulphate is decomposed and a compound of iron, oxygen and water formed, known as hydrous ferric oxide, or limonite ($2Fe_2O_3+3H_2O$). These changes are expressed by the following equations readily intelligible to those having studied chemistry.

$$4FeCO_3+7H_2O+2O=(2Fe_2O_3+3H_2O)+4H_2CO_3$$
$$4FeSO_4+7H_2O+2O=(2Fe_2O_3+3H_2O)+4H_2SO_4$$

When the deposit is sufficiently pure, irregular, brownish-yellow lumps are formed which are known as "bog ore," local deposits of which occur in numerous parts of the township and in an early day were of economic importance. When the deposit goes down in earthy condition, with more or less impurity, it is known as "yellow ochre" and when ground and mixed with oil has value as paint. Upon standing under certain conditions, this form of the oxide is changed to the ferric oxide, hematite (Fe_2O_3), which contains no water chemically united with it, although often mechanically mixed therewith. This has a cherry red color and when earthy is known as "red ochre," valuable also as a pigment. An extensive deposit, mostly of the yellow but with some of the red, occurs a mile west of Martinsville in Sumpter township (secs. 9, 10, 15 and 16), reputed to be a mile square and an average thickness of 6 to 10 feet. It is said to rest upon marl which indicates that it is a younger and true swamp deposit. Other deposits are reported from secs. 6, 18, 20 and 22. Some 7 or 8 years ago a company ("Huron Valley Consolidated Oil and Paint Co."; Thomas W. Boatwright, President, Ypsilanti, Mich.) was organized to put this material upon the market. Land was purchased and some farms leased and the intention was to erect a factory at Belleville, but there the matter still rests.

MATERIALS AS ABRASIVES.

When examined under the microscope, much of the Sylvania sand is seen to have been secondarily enlarged, crystal faces having formed over the well rounded granules, giving highly perfect edges and points. Such sand is peculiarly well adapted to serve as an abrasive, wherever loose sand can be utilized; as in scouring, sanded surfaces, sand blasting, etc. Along Raisin River, in the neighborhood of the outcrop in Monroe County, the farmer's wives have long known of its superiority over the common sand of the region for scouring kitchen utensils. Owing to its purity, whiteness and sparkle, it has proven popular with the match manufacturers to supply the rough surface placed upon each box. It should make a very superior soap of the *sapolio* type, when supplied in the proper proportions. For use in aquaria and in schools where sand moulding is carried on, the Sylvania has no superior. An exceedingly fine grayish sand obtained from the Huron valley has been placed upon the market and sold locally by Frank Miller, of Belleville. It was advertised as "Deep down Polish" and recommended for iron, tin, brass, copper and silverware. The individual grains can just be detected with the naked eye when spread thinly over a dark surface and when rubbed between the fingers; under the microscope appearing as sharply angular mass of grains, chiefly quartz. The sand probably represents a delta deposit of the Huron during one of the ancient lake stages.

MATERIALS FOR FUELS.

Peat. The waters of the glacial lakes lingered so long over the more poorly drained portions of Wayne County that no extensive beds of peat were able to form. The production of this type of material requires shallow water, or swamp conditions, for the favorable growth of the mosses and sedges (*Sphagnum* and *Carex* principally), and for their subsequent preservation. The sites of the more extensive swamp areas, previously located (see Pl. X), furnish deposits of peat, but are probably of no great thickness, and, at present, of little commercial value. The utilization of peat as a fuel is seriously retarded by the expense of drying, this

being done by the sun in many countries where peat is extensively used as a fuel. For commercial purposes, this seems so far to be impracticable. The production of gas from peat is now possible by placing the partially dried product in an especially designed retort, with a certain amount of air and superheated steam. The by-product is ammonium sulphate ($(NH_4)_2SO_4$), which has high value as a land fertilizer. The use of fibrous peat as litter in bedding stock is also to be strongly recommended. When used as an absorbent for the liquids about the barn yard that are wasted the peat becomes even more valuable than the leached manure itself. A discussion of the occurrence, origin, composition and properties of peat will be found in the Ann Arbor Folio.[6]

Oil and gas. Much money has already been expended in searching for oil and gas in southeastern Michigan, but with practically nothing in the way of direct returns. As a result of these enterprises, however, we have learned much concerning the geological substructure of this portion of the state, of its water-bearing horizons and through the log of the deep well at Wyandotte in 1887 (Eureka Iron and Steel Works) the presence of rock salt was made known. This discovery has meant more for the industrial development of Wayne County than any reasonable amount of oil and gas could have done. It has also shown that there is no justification for further heavy expenditures in the search for oil and gas, since the rock strata are dipping to the northwestward and these desired products appear to have shifted to the Canadian fields about Leamington. The heavy flows of pocket gas, often encountered when the Antrim shales are penetrated will continue to arouse false hopes and stimulate unwise expenditures in the future as in the past. This gas at times shows pressures of a hundred pounds, or more, to the square inch and if confined properly could be utilized by the farmers for cooking, heating and lighting their homes and in caring for stock. Just over the Base Line in Oakland County, W. J. Purdy has a 110-foot well (SE. ¼ NW. ¼ sec. 25, Southfield township) which has supplied his home with fuel for 16 years, the original pressure being 37 lbs. to the square inch. Under the terms of a lease to outside parties 5 other holes have been drilled, all but one yielding gas. The supply from each well will be exhausted, sooner or later, which may be replenished by sinking a new well.

Since fragments of this shale will often burn with flame when placed in the fire, it has been mistaken for coal and efforts made

6. C. A. Davis, U. S. Geological Survey, No. 155, p. 8. See also Report of the State Board of Geological Survey of Michigan for 1906, p. 92 and 1908, p. 205.

to start mining, as reported from near Belleville. As a bed, it contains great quantities of gas, oil and other combustibles, which might be secured by distillation, but which will not become commercially valuable until our present fuel supply is more nearly exhausted. Upon the estate of W. H. Stevens, NW. ¼ NE.¼ sec. 13, Greenfield township, the experiment was tried for a few years of manufacturing lampblack through the incomplete combustion of this natural gas, causing the carbon to be deposited. The experiment was not especially successful and was given up about 12 years ago.

CHAPTER IX.

SUMMARIES BY CIVIL DIVISIONS.

To furnish residents of the county with condensed information relating to their own or neighboring localities and to point out the near at hand illustrations of the various features discussed in the body of this report, it is proposed to devote this chapter to a set of summaries by townships. The classification adopted is genetic, and hence natural, and groups together townships which are related in topography, soils, agricultural products, problems of drainage, water-supply, roads, etc. Most of the townships fall readily into some one of the main divisions, some of them overlap the natural areas so that they combine characteristics of the two and have been placed in the division that appears dominant.

MORAINIC AREAS, UNDULATING SURFACE AND CLAY SOILS.

Northville township. T. 1 S., R. VIII E., (northern part). Named from village when it was detached from Plymouth township in 1897. Township lines were originally surveyed by Alexander Holmes in 1815 and subdivided the same year by Joseph Wampler. Area 18.270 square miles; population 2274. Surface rough with knolls, ridges and depressions strewn with surface boulders; soil mainly stiff clay of glacial origin; many of the hills composed of gravel and sand of the type known as *kames.* The highest elevation in the township (the county as well) lies in the NW. ¼ sec. 6 and equals about 980 feet above sea level; the lowest is at the SE. corner (sec. 13) and is about 715 feet. A broad glacial drainage channel extends southwestward from Northville village, across secs. 3, 4, 9, 8, 17 and 18, floored with gravel and sand, once carrying the drainage of the ice sheets to the southwestward, while the ice was forming the Defiance moraine, lying just to the eastward. This moraine covers conspicuously the eastern half of the township excepting sec. 13 and is drained into the Middle and Upper Rouge. The drainage of the old glacial channel noted is now *reversed* being to the northeastward. West of this channel lies the Northville moraine, involving secs. 4, 5, 6, 7 and 18, many of these hills being kames. The northwestern half of sec. 6 was coated with more or less sand and gravel by the glacial outwash when the ice was

forming this Northville moraine. The Upper Maumee beach cuts southwestward from the NE. cor. sec. 12 to the SW. cor. sec. 14, lying just above the 800-foot contour, showing also in the depression that crosses secs. 1 and 2. The Middle Maumee beach enters the township in the SE. ¼ NE.¼ sec. 12, showing excellent development in sec. 7, Livonia, and passes southwestward just above the 680-foot contour. The Lower Maumee beach enters in the NE. ¼ SE. ¼ sec. 12, lying above and parallel with the 660-foot contour. All three beaches mark the successive shore lines of the old glacial Lake Maumee, consist of disconnected ridges of gravel and sand, approximately parallel and with a NE. to SW. trend. The best place to identify and study them is along the N-S road at the eastern margin of sec. 12. The lowest of the series is the least well defined, which is believed to indicate that it was formed before the middle one and was then washed over while the middle was forming. The outlet of the first of the series of lakes was at Ft. Wayne, Indiana, into the Wabash and later by this and another at Imlay City into Grand River to the site of Chicago. Eastward of these beaches, the land was submerged for a time, including the SE. ½ of secs. 12 and 14 and all of 13, by which the morainic knolls were lowered some and smoothed and the hollows between partially filled. The diagonal road through the SE. corner of sec. 13 is carried upon a still better defined gravel beach, known as the "Belmore" or "Whittlesey beach," the shore line of Lake Whittlesey, which drained across the "thumb" at Ubly, into the Grand. Northville township is well supplied with springs of pure cold water, from its gravel and sand deposits; but getting water from the clay hills is uncertain, the supply being meager in amount and often obtained at considerable depth (8 to 125 feet), invariably hard, but free from sulphur or gas. The bedrock is buried by 90 to 250 feet of clay, sand and gravel ("drift") and consists of light colored shales, sandstone and some limestone, yielding fresh water under sufficient "head" to nearly reach the surface in the depressions. The township was originally forested with a heavy growth of black walnut, beech, maple, oak and hickory, with some birch and bass.

Plymouth township. T. 1 S. R. VIII E., (southern part). Probably named from locality in Massachusetts; established in 1827; included Canton until 1834 and Northville until 1897. Township lines surveyed by Alexander Holmes in 1815 and subdivisions made the same year by Joseph Wampler. Area 19.140 square miles; population 2248. The western half of the township is rough, rolling morainic topography, rendered so by short, slightly curved and ir-

regularly placed clay ridges of the Defiance moraine, with much less gravel than is found in Northville. Field boulders and cobbles strew the surface as they were dropped from the ice sheet. The outwash glacial drainage channel, located in Northville township, extends across sec. 19 giving some sand and gravel; slack drainage and swampy. A somewhat flat ground morainic area extends NE. to SW. across secs. 29, 30 and 31. The Upper Maumee beach, in the form of a disconnected gravel ridge, pursues an irregular, wavy course across secs. 22, 28, 33 and 32 into sec. 5 of Canton, just above the 800-foot contour as it follows along the dissected eastern flank of the Defiance moraine, marking the highest stage of the glacial waters in this region. The Middle and Lower Maumee beaches roughly parallel the Upper, at a distance of ¼ to ½ mile to the eastward, but are disconnected and rather difficult to follow. Their lakeward slopes determine the location and general direction of the 680 and 660-foot contours passing through secs. 22, 27, 28, 33 and 32. A good location in which to see all three is along the N-S highway between secs. 32 and 33, the Upper being seen just where this road is crossed by the diagonal road leading towards Plymouth, while the Lower crosses the town-line at the SE. corner of sec. 32. Along the line of the Pere Marquette Ry., leading west from Plymouth, a good section of the Lower Maumee may be seen ½ mile west of the station (SE. ¼ SE. ¼ sec. 22), and of the Upper about ¾ mile further west, with the middle less well defined and lying between. The Belmore or Whittlesey beach, marking the margin of glacial Lake Whittlesey, is a splendidly defined gravel ridge, carrying the diagonal road which passes SW. across sec. 24 to where it is intersected by the diagonal road from the NW. Here the beach leaves the road, curves to westward entering sec. 26 near the NE. corner and pursues a very direct course SW. across secs. 27, 34 and 33. In the village of Plymouth, it has determined the direction of the main residence street and the beautifully graded sites for the homes, at an elevation of approximately 736 feet above sea level. Eastward of the Whittlesey beach, the topography is relatively flat, the soil a gravelly, sandy loam as a result of the delta deposits of the Middle Rouge during the glacial lake stages, involving all of secs. 25, 35 and 36, the greater portions of secs. 24, 26 and 34 and the SE. corners of secs. 27 and 33. Over this delta deposit there occur in secs. 26 and 36 a few low gravel or sand ridges, having a course N. NE. to S. SW., representing bars in the old lake, or washed over beaches of Lake Arkona stage, which were supposed to have been formed before the Whittlesey, an advance of the ice dam then

forcing the water to the Lake Whittlesey level. The highest elevations are found at the NW. corner of sec. 20 and the adjacent NW. corner of sec. 21, along the crest of the Defiance moraine, rising to 880 feet above sea level. Outside the bed of the Rouge, the lowest elevation is at the SE. corner of sec. 36 where it is close to 690, giving an extreme relief in the township of 190 feet. The drainage of the NE. and NW. corners of the township is into the Middle Rouge, the remainder into the Lower Rouge. The bedrock consists of the "Coldwater shales," which are light colored and interstratified with seams of sandstone and some limestone. They are covered by from 90 to 250 feet of clay, sand and gravel, the depth to rock at Plymouth being 100 feet and having an elevation above sea level of about 635 feet.[1] The elevations of the rock surface probably do not differ greatly, apparently rising some to westward, the great differences in the thickness of the rock cover being due mainly to the morainic features noted. So far as known, the water from bedrock is not highly mineralized and contains no notable amounts of gas or sulphur unless the underlying black shales are reached. At Plymouth, the head of this water is about 725 to 735 feet. Over the morainic area, springs occur but not as abundantly as in Northville township, since the gravel hills are not so numerous, and the problem of getting well water is somewhat uncertain. The wells range in depth from 14 to 80 feet and yield a hard water; often abundant but sometimes all too meager. East of the Whittlesey beach the wells are shallow as a rule, 9 to 18 feet, the delta deposit reposing upon the clay and attaining a thickness of some 18 to 30 feet. On the beach itself the gravel is 20 to 25 feet in thickness, yielding a limited supply of hard water, liable to contamination. In section 34, within ¾ of a mile of the Whittlesey beach there occurs a cluster of flowing wells from 50 to 70 feet in depth, rising some two to three feet, containing iron but little other mineral besides and having a temperature of 51° to 52°. The natural forest growth over the morainic, clay areas was walnut, hard maple, beech, whitewood, oak, white ash, rock elm and basswood. Over the sandy gravelly loam areas; elm, black ash, whitewood and hard maple.

Monguagon township. T. 4 S., R. X to XI E., (in part). Passing from the western part of the county to the extreme eastern we have a strip of territory that has much in common with it. This township was named from the old Potowatamie chieftain; was origin-

1. At the cemetery, a driller reports having gone to a depth of 250 ft. without striking rock. If this is not an error it would indicate either a fissure in the rock filled with drift, or a great trough having a depth below the general rock surface of at least 150 feet. Further records are required to settle this point.

ally surveyed by Joseph Fletcher in 1816 and 1817; established in 1827; has an area of 23.355 square miles and a population of 3367. It includes Grosse Isle and some of the smaller adjacent islands. Except for a narrow, sandy strip running southward through secs. 11, 14, 23 and 26, marking the level of the First, or Upper Lake Rouge beach (elevation about 594 feet), the soil of the township is stiff, glacial clay, sparingly strewn with boulders and cobbles and having a gently undulating surface. These undulations are very different in appearance from the ridges and knolls of Plymouth and Northville townships, consisting of approximately parallel, N-S. corrugations in the clay, varying in height from 1 ft. to 12 or 15 ft. These are highest in the vicinity of Trenton where they rise some 28 feet above the river level (elevation 602 feet) and upon the western half of Grosse Isle, gradually becoming lower toward the westward and dying out on the flat till plain just over the township line in Brownstown. In Amherstburg, opposite in Ontario, the same type of ridging is seen, also fading out to the eastward. These ridges were formed at the front of the ice sheet, in some 225 feet of water, the oscillations of the ice wall gouging into the clay of the ground moraine and pushing it up into these regular ridges, dropping on top of them whatever stones were brought to the margin of the ice. These features constitute the Grosse Isle moraine and while they were forming, the shore line of the glacial lake (Maumee) was in the vicinity of Plymouth and Ypsilanti, with its drainage through the Imlay channel into Grand River and Lake Chicago. Some of the depressions between these glacial ridges were occupied by streams of water (the "distributaries" of Taylor) when the level of Lake Rouge fell from its higher to its lower stage (elevation about 590 to 580 above sea level). The current was probably not great and the cutting and deposition were correspondingly small. One of the most conspicuous and typical of these distributary channels leaves the Trenton channel of Detroit River, just north of the Church and Co. abandoned plant, curves to the southwestward, about ½ mile west of Trenton, branches in the SE. ¼ sec. 24, gives off a number of minor branches to the southeastward in sec. 25 and itself joins Brownstown Creek. The "thoroughfare" on Grosse Isle is of the same nature, crossing diagonally to the southwestward and sending off a branch opposite Slocum's Island. Even where not of the nature of distributaries, the ridges control the present drainage, forcing it into the depressions which slope to the southward; good illustrations of very young, consequent streams. The highest land in the township is over the crest of the moraine, along

the road between secs. 6 and 7, reaching approximately 605 feet above sea level, or about 31 feet above ordinary river level. Along the eastern flank of this elevation, at Wyandotte Heights, the First Rouge beach shows somewhat poorly, extending southward through the western part of sec. 5, and southwestward across sec. 7. Just opposite upon Grosse Isle, the same poorly defined, gravel ridge curves about the head of the island. Monguagon township was submerged during the second and third stages of Lake Maumee and during the lives of the entire series of glacial lakes to the first stage of Lake Rouge, when the crests of the higher morainic ridges had emerged from the glacial waters. In spite of this long submergence, conditions were not favorable for the deposition of lake sediments in the form of clay; the glacial clays, cobbles and boulders showing upon the surface. The bedrock consists of Dundee limestone over the northern portion of the township and Upper Monroe dolomite over the southern portion of the mainland and Grosse Isle. Natural outcrops occurred at Sibley, Stony Island and the southern part of Grosse Isle. At the two latter places quarries into the dolomite have been opened and abandoned, while the limestone quarry at Sibley (sec. 7) is in very successful operation. The drift cover increases most rapidly to the northward attaining a thickness of 70 to 80 feet on the town line between Monguagon and Ecorse, and at the head of Grosse Isle. Water is ordinarily obtained from layers of gravel or sand in this drift at variable depths. Springs are not abundant owing to the scarcity of surface gravel and sand deposits. Northward through secs. 25, 24, 13, 12 and 1 there have been strong flows of artesian water, with some sulphur, but practically all have ceased flowing, for reasons not yet positively known. The native forest growth is white and black ash, hickory, walnut, beech, hard and soft maple, elm, basswood, yellow and white oak, whitewood, cottonwood and sycamore.

City of Detroit (City of the "strait") T. 1 and 2 S., R. 11 and 12 E., (in part). Founded in 1701; incorporated as a town in 1802; as a city 1806; charter repealed in 1809 and regranted in 1815. Area approximately 42 square miles; population 465,766. Although in the vicinity of the suburbs, there occurs considerable sand and the type of ridging that accompanies this soil, the city is built upon a broad clay ridge, the Detroit moraine, which appears in the vicinity of Birmingham, passes southeastward, crosses the river to Windsor and continues southeastward across Essex County. The highest elevation in the city is in the vicinity of Voigt Park, out Woodward Avenue near the city limits, where the sand covered morainic surface rises from 636 to 638 feet above sea level, or

some 62 feet above river level. The slope is rather gradual to the southeastward, across Woodward Avenue, in the direction of Elmwood Cemetery, becoming steeper as the ridge narrows and curves slightly to the west of the cemetery. From the city limits, along the crest of the ridge to Gratiot Avenue, the average slope is but 3 feet to the mile, while, beyond to the river, the average slope is about 34 feet to the mile. From the crest of the ridge, the slope is gentle and rather regular to the southeast and southwest. This moraine is believed by Taylor to have been formed *sub-glacially*, (as an "interlobate") along the line of junction of the Huron and Erie lobes of ice during the final stage of the Late Wisconsin, thus accounting for its smoothness and generally subdued character, its breadth, direction, location and freedom from boulders. For a distance of two miles back from the river, across the crest of this moraine and upon its eastern and western flanks, there occurs a series of corrugations similar to those just described in Monguagon township and believed to have been formed in the same way and at the same time. They may be seen typically by passing out Gratiot Avenue to the vicinity of Joseph Campau Avenue and for a distance of two miles from the City Hall out Michigan Avenue by glancing along the side streets. They are believed by the writer to represent the ridges of a water-laid moraine, pushed up by the rythmic movements of the ice-front, extending across the previously formed Detroit moraine, in some 150 to 200 feet of water. Those to the eastward of the crest of the ridge would be arbitrarily assigned to the Huron lobe of ice and those to the westward to the Erie lobe, and hence to be part of the Grosse Isle moraine which passes from the head of that island to Detroit upon the Canadian side of the river. Those ridges for which the Huron lobe was responsible may be connected with the Mt. Clemens moraine, which comes in from the north, but the writer believes that they are directly connected by additional and similar ridges with the Emmet moraine which passes along the eastern shore of Grosse Point township to Milk River Point, there entering Lake St. Clair.

Belle Isle and Isle aux Peches, in the upper Detroit River, probably owe their existence to this same moraine, these islands representing ridges which have been emphasized by stream action, exactly as have those in the lower Detroit region where the correlative moraine crosses the river. The lake chart shows a submerged ridge between Belle Isle and Detroit lying mainly to the north of the bridge and parallel with the others. In the vicinity of the river, some of these ridges have been emphasized by stream action, two of the depressions having furnished the beds of "distributary channels," similar to those described as occurring near Trenton. The Detroit moraine is conceived of as a dam when the waters of the First St. Clair stage were dropping to the next lower stage and through these depressions the currents coursed, carrying much sand and gravel and depositing it in the vicinity of Ft. Wayne and Clark Park in the western part of the city, obscuring the glacial clay. Congress Street, eastward of Woodward, marks the axis of one of these distributary channels and the depression along Labrosse and Baker, to the west of Grand Circus Park, seems to have served as another. Others probably existed in what is now the channel of the river. These ridges subsequently controlled the surface drainage of the region, to a large extent, until deflected by sewers.

The present site of Detroit remained submerged during the entire series of glacial lakes from Maumee to Lundy, 2nd stage. During the 1st stage of this latter lake, the main shore line was just north of the present city limits, in Highland Park, but disconnected sand bars and beaches were being formed in the northern and northeastern portions of the city at elevations of 630 to 636 feet above sea level, showing that the present site was just awash. One of these sand ridges crosses Woodward at right angles between Schiller and Shakespeare streets, on the west and Boston and Chicago upon the east, extending towards Kenwood Station, turning SE. on Oakland and then to the south from Mott as far as Koch, one block east of Woodward. A similar, but not so sharply defined sand belt, has a southerly course, about ½ mile west of the Milwaukee Station and a second roughly parallel and just east of Harper Avenue. To the second stage of Lake Lundy, the water dropped about 25 feet uncovering much of the present city's site, and depositing considerable sand to the north and east of Elmwood Cemetery, between the contours of 610 and 620 feet, along, but mainly to the east of Gratiot. In the opposite part of the city, this shore line (Elkton) is indicated by a sand ridge, having a general easterly course through Beech Hearst, north of Warren Avenue, crossing Warren in the vicinity of 27th Street and continuing as far as 17th, where it dies out, having followed closely the 610-foot contour. In passing around the nose of the Detroit moraine, just west of Elmwood Cemetery, there seems to have been more current action, since we find a cut bluff instead of a sand ridge, well shown between Monroe and Macomb streets, in the vicinity of Joseph Campau Avenue, but continuing eastward and westward for many blocks. Standing at Grand Circus Park and looking out Woodward the cut bluff shows plainly, between

Columbia and High streets, although grading has interfered some with its distinctness. Lake Lundy during both stages drained through Mohawk River eastward while the ice front is believed to have stood in the vicinity of Alpena. Between the contours of 590 and 595 feet, and following Jefferson Avenue quite closely throughout nearly its entire length, another cut bluff marks the water level of the First Lake St. Clair, a little sand having been deposited to the northwest of the Waterworks. In the vicinity of Wayne Street, this water line crosses Jefferson to the westward, intersecting Larned, Congress and Fort streets and roughly following Lafayette as far as the Boulevard. Somewhere along its course this beach line changes to that of the First, or Early Lake Rouge, the waters of which took the sand deposited by the distributaries noted above and heaped it into beach and bar ridges between Clark Park and Woodmere Cemetery, Ft. Wayne and West Detroit. The lower beach of lakes St. Clair and Rouge, just above the 580-foot contour, may be seen in the vicinity of the Waterworks and of Ft. Wayne, but between has been largely obliterated by grading and water front construction.[2] During the existence of the early lakes Rouge and St. Clair, the drainage of Lake Algonquin, their correlative to the north, shifted considerably, being at one time at Trent, Ontario, at Chicago and through these two lakes into Lake Erie. The ice had retreated far to northward, finally withdrawing into the Mattawa and Ottawa valleys. The lower stage of lakes Rouge and St. Clair is correlated with the Lakes Nipissing, the disappearance of the ice in the Georgian Bay region, allowing drainage by North Bay, Ontario. The thickness of the drift ranges from 90 to 160 feet, overlying the bedrock, consisting almost entirely of Wisconsin till, only sparingly charged with rock fragments and so soft that it can be easily cut with a spade. Lenticular masses of quicksand and occasional strata of gravel occur, charged with fresh water. The clay is largely leached of its lime carbonate to a depth of 12 to 15 inches and oxydized often to a depth of several feet. The occurrence of quicksand in the till may make the taller buildings very insecure upon their foundations, requiring the use of piles, or the placing of the supporting masonry upon bedrock. Only a full series of borings should be relied upon to prove the absence of such quicksand deposits at each locality. The bedrock underlying the city is largely limestone of Traverse (Hamilton) and Dundee ("Corniferous") age, the elevation of the surface of which ranges from about 440 to 500 feet over the greater part of the city. In the preliminary borings for the tunnel, "sandstone" is reported in a number of cases, but in view of the full development of Dundee at Oakwood, in Windsor, and at the Ford building, and the fact that no sandrock is to be expected at this geological horizon, the identification may be seriously questioned. The rock surface drops slowly to the eastward being about 457 feet above sea level at the head of Belle Isle, culminating in local depressions in Gratiot and Hamtramck townships. Were it not for the drift, the present site of Detroit would be covered by an average of about 85 to 90 feet of water. In the early days, the settlers obtained their water directly from the river but an increase of population rendered this inconvenient and a system of public and private wells was made use of, these being dug to the water-bearing strata in the sand and walled up with stone. In the summer of 1829 a deep well was sunken by The Hydraulic Company on the south side of Fort Street, between Shelby and Wayne, to a depth of 268 feet and 4 inches in diameter, bedrock ("geodiferous limerock") being reached at a depth of 127 feet. Water in sufficient quantity was not obtained and recourse was again had to the river. A crude pumping plant was begun in 1825 to use the river water, the mains being made of hollowed tamarack logs and the pump was driven by horse power. Water from the bedrock is highly mineralized and contains sulphur. The head in the western part of the city reaches 595 feet, rises to the north and west and drops slowly to the eastward, being about 580 at the Murphy Power Plant, corner Wayne and Congress streets. The temperature of this water may range from 49.5° to 52.5°F., so far as may be judged from the half dozen records available. The original forest growth was white and red oak, ash, whitewood, cottonwood, walnut, butternut, beech, birch, hickory, elm, maple, basswood, cedar, etc.

2. A good point from which to view this lower beach is just west of the Waterworks, on Park View Avenue, where it may be found about 300 paces toward the river from Jefferson Avenue. From same point the cut First St. Clair beach is in sight upon the opposite side of Jefferson.

Grosse Point township. T. 1 to 2 S., R. XIII E., (in part). Named from the large point of land constituting the northeastward corner of Wayne County. Separated from Hamtramck township in 1848, contributed to Gratiot in 1903. Approximate area 11.310 square miles; population 3,579. Surface rendered undulating by the Emmet moraine which follows the shore line, the crest of which rises to 620 feet, near the center of the township, or about 45 feet above the lake level. Drainage is to the southwestward by Fox Creek and to the northeastward by Milk River, lying to the westward and being deflected by the morainic ridges. The

divide between the two streams is poorly defined, in the western part of the township, opposite Vernier. The entire township was subdivided into "French claims," running back from the water front, the direction of which determined the course of the roadways and private lanes, with a NW.-SE. trend, as well as those which crossed the claims at approximately right angles. The exact location of these latter was determined very largely by the NE.-SW. sand ridges of the first stage of Lake St. Clair. Soil mainly a glacial clay, with some surface dressing of sand and a little gravel, but with few cobbles and boulders distributed over the surface. In the northeastern part of the township the moraine lies nearer the lake shore, has been cut into by wave action and there has been a concentration of boulders and cobbles which have partially protected the bank from further encroachment (Pl. XI, B). In addition to this protection, trees, brush, logs, piles, planking and breakwaters have been used to prevent cutting. Since French occupancy, it is estimated that 1000 feet have disappeared to the east of Jefferson Avenue at one place, carrying away a cemetery and orchard; some 130 feet having disappeared during the past 30 years in the vicinity of Vernier Road. Farther north a settler's house had to be moved back twice to keep it from falling into the lake. A fragment of a till ridge, about a mile lakeward from the main ridge of the moraine, lies just eastward of Windmill Point and enters the lake forming a bluff 12 to 14 feet above lake level. Between this point and Fairview Village considerable marshy land and muck borders the lake. In the depression occupied by Fox Creek and Milk River, there is some marsh, mucky soil and more or less lake clay deposited. During the first stage of Lake St. Clair, the township was under water except for an elliptical island, about two miles long by one mile broad, extending from Claireview to Grosse Point Farms, rising about 20 to 25 feet above the water. The narrower portion of this crest existed as a bar during the Elkton stage of Lake Lundy, the main shore line lying some 3 to 4 miles to the west. Upon both the eastern and western slope of this island, sand and gravel ridges were deposited during the life of the two preceding stages of Lake St. Clair, the eastern lying near the present shore line and parallel with it, the western having the same NE.-SW. trend and about a mile to westward, rising to the height of 620 feet. From Grosse Point Farms, two ridges of sand unite from opposite sides of the island and extend W.-SW. as a single ridge, attaining a height of 600 feet, and giving an irregular and more or less disconnected belt of sand to the north of Jefferson Avenue and curving around to

St. Clair Heights. The second stage of the lake formed a sand ridge between 580 and 585 feet, which is followed closely by Jefferson Avenue, especially well shown at Cottage Grove, where the ridge has deflected the course of Fox Creek to the westward and lengthened the stream by some two miles. From Grosse Point Farms, to the northeastward, this beach lies mainly on the lakeward side of Jefferson and has been largely destroyed by wave action of the present lake. A second sand ridge was thrown up by the waves about 1½ miles to the westward, parallel with the present shore to an elevation of 484 to 488 feet above sea level; determining the location of Mack Avenue for its last four miles in Wayne County. This sand is 5 to 6 feet thick, rests upon blue clay, and yields a poor supply of moderately soft water. Obtaining water from the glacial clay is uncertain, requiring depths of 15 to 80 feet; water hard. Rock records are meager in the township, the depth to which ranges from 90 to 160 feet, the extreme southern portion of the township being apparently underlain by limestone and bluish shale (Traverse) and the remainder by the black shale (Antrim). The latter generally gives gas, with some sulphur; the former formation generally yields water more or less charged with salt. The head is insufficient to bring the water to the surface except on the old Woodbridge estate (claim No. 183), just south of the Vernier Road upon Jefferson Avenue, where rock was struck at 95 feet and entered .5 foot, the water rising a foot above lake level, marking the beginning of a belt of flowing wells which become numerous along the lake front in Macomb County. The native timber was elm, oak, basswood, black ash, hickory, sycamore, with some beech, maple and whitewood.

Gratiot township. T. 1 S., R. XII to XIII E., (in part). Named from Col. Charles Gratiot. Established in 1903 from portions of Hamtramck and Grosse Point; area 19.425 square miles; population 1900. Rectangular survey by Joseph Fletcher in 1816; eastern and southern parts of township made up of "French claims" from Lake St. Clair, Detroit River and Conners Creek, causing much irregularity in the direction of highways, both as to their direction and spacing. The soil is very largely a glacial clay, but with relatively few boulders and cobbles strewing the surface and flat, smooth topography, with slopes changing from east, through south around to southwest, directing the drainage to Milk River, Fox Creek and Conners Creek. The township contains the southern extension of the Mt. Clemens moraine, much better defined to the northward, but here a broad, poorly defined swell of glacial clay with no perceptible ridging. It was deposited under water, at a

depth of 165 to 175 feet, the ice margin having here none of the gouging, pushing effect that marked the formation of the Emmet and Grosse Isle moraines. Just northward in Warren and Erin townships, boulders and cobbles are much more in evidence. The main slope of the township is slightly south of east and averages but about 8 feet to the mile, dropping from 629, at the extreme NW. corner (sec. 2), to about 588 along the eastern border. The even topography and clay soil are interrupted in secs. 2 and 11 by an irregular set of sand ridges, some 10 to 12 feet above the general level, representing shore deposits in the early stage of Lake Lundy and more or less modified by subsequent wind action. When the waters of this glacial lake fell to the Elkton stage (about 635 to 610 feet, above sea level), the shore lay to the east of Gratiot Avenue, where on the shallow and gently sloping strand, small, disconnected ridges of sand were formed over an area, ½ to 1 mile broad, reaching from the Base Line to Conners Creek. The wave action does not seem to have been heavy, in part accounted for by the presence of the morainic ridge and island in Grosse Point township. When the water level fell to the First Lake St. Clair stage, wave action continued slight, apparently because the force of the waves was broken to eastward, and a small notch, 12 to 18 inches deep, was cut in the clay, with practically nothing in the way of deposit. This starts just where the Vernier Road joins the Base Line, passes across the claims, veering slightly to the west and curving around to where Mack Avenue crosses Conners Creek. In this vicinity, passing from behind the island above noted, the wave action appears to have been greater and a sandy ridge was formed. The course of this shore feature was mapped before the topographic map was made and was found to be almost exactly parallel with the 600-foot contour, and at an elevation of about 595 feet. Medium hard to soft water is obtained from the sand areas at shallow depths. Over the clay portions of the township hard water is obtained only at variable depths and in varying quantities, depending upon how successfully the water bearing horizons are reached. These wells range from 9 or 10 feet to bedrock, which varies from about 110 feet in the eastern part of the township to 135 in the western, increasing to some 160 or 170 feet at the south. The elevation of the rock surface ranges from 420 to 500 feet above sea level, dropping to about 420, where the depth is greatest to the south of Conners Creek. This rock is mostly black shale (Antrim) and yields gas in small quantities. Ground water nowhere reaches the surface, falling short by some 5 to 20 feet, the head ranging from 600 to 612 feet. The

original forest growth of this region was white and black ash, basswood, white oak, beech, hard maple, butternut and some walnut.

TILL PLAIN AREAS, FLAT SURFACE AND CLAY SOILS.

Canton township. T. 2 S., R. VIII E. Named from city of China. Derived from Plymouth township, established in 1834. Township lines surveyed in 1815 by Alexander Holmes; subdivided in 1819 by Joseph Wampler. Area 35.935 square miles; population 1113. Soil largely a stiff glacial clay; only restricted sand and gravel areas. Although submerged by the glacial lakes Maumee, Whittlesey and Arkona, there are no recognizable lake deposits from their waters. All but about 4½ square miles of the township is remarkably level and flat, left smooth by the Late Wisconsin ice sheet as it retreated from west to east. Two square miles at the northwestern corner (sec. 6 and portions of 5 and 7) are rough and rolling because of the Defiance moraine, formed at the front of the ice sheet during a stage of halt. This crosses from Plymouth, southwestward into Superior township, much of it above the 800-foot level, reaching 850 feet at the extreme NW. corner. This small area has all the characteristics given for Plymouth and Northville townships, of which it is geologically and physiographically a part. The eastern flank of this moraine held back the waters of Lake Maumee during its three stages and more or less continuous ridges of sandy gravel were built along the slope from materials washed out of the clay. The morainic knolls were thus subdued and the slopes rendered more regular as is indicated by the course of the 800, 780 and 760-foot contours. The three beaches cross secs. 5, 6 and 7, roughly parallel, from NE. to SW. and from ½ to ¾ of a mile apart. The first, or upper, is the less well defined and most difficult to follow as it was made when the lake was narrow and wave action relatively slight. It crosses the NW. corners of secs. 5 and 7 and the SE. portion of sec. 6. The third, or lowest, beach is the most direct and continuous, cutting diagonally through secs. 5 and 7, while the middle, lies about half way between these two. The most advantageous point from which to examine the series is at the SE. corner of sec. 6. From a half to a mile SE. of the Lower Maumee, and roughly parallel with it, lies the much more conspicuous and better known "ridge," known as the Belmore, or Whittlesey beach, standing some 10 to 15 feet above the general level, and having an elevation of 735 to 740 feet. Except for short distances at two points, this beach has furnished the site for the diagonal road in

secs. 18 and 19 of Canton and sec. 25 of Superior (Washtenaw County), enters sec. 8 at the SW. corner, crossing the section to the west of the center, then crossing the SE. ¼ sec. 5 and the NW. ¼ sec. 4. Being so typical throughout its course, it may be observed to advantage at any point. It contains some 20 to 25 feet of gravel and sand and furnishes a desirable site for farm buildings, a number of houses in Cherry Hill being so placed. The slope from this beach to the southeastward is regular and relatively rapid to the 720-foot contour and then so gentle as to be barely perceptible to the eye, dropping to about 667 feet at the SE. corner. The drainage is thus deflected eastward into Tonquish Creek, a tributary of the Middle Rouge, and southeastward into the Lower Rouge. From the second stage of glacial Lake Maumee, with drainage at Ft. Wayne, Indiana, into the Wabash and at Imlay City, into the Grand River Valley, the waters are believed to have dropped to the Arkona stage, during which drainage was around the "thumb" directly into the Grand. The level of the lake waters fluctuated and built up ridges from about 695 to 710 feet above sea level, when an advance of the ice covered the tip of the "thumb" again, raised the level of the water to the Whittlesey stage and forced the drainage across at Ubly into the Grand River Valley. The Arkona beaches were thus submerged and to some extent obliterated so that they may be traced often only with difficulty. They pass northward from Dentons through secs. 32, 31, 30, 29, 28, 20, 21, 15, 16, 17, 8, 9, 10, 4, 3, 2 and 1. A good development is seen at the NE. corner sec. 30 and in the NW. ¼ NW. ¼ sec. 1. The Warren, or Forest beach, passes northward through the village of Canton as a moderately well defined gravel ridge, just above the 680-foot contour, crossing through the middle of secs. 34, 27 and 22, fading out for a couple of miles and reappearing in 11, 2, 12 and 1. Some sand was blown, or washed westward from the Wayne beach in Nankin township and forms a thin veneer over the eastern row of sections from north to south. The NE. and SW. corners of Canton township extend into the gravelly sand deltas of the Middle Rouge and Huron rivers, representing deposits formed during the Arkona stage of the glacial lakes. Considered as a whole Canton township is at present the best watered of any in the county, containing the largest number of flowing wells and the best quality of water. These wells lie to the east of the Whittlesey beach, distributed over a belt three miles broad, crossing the township from northeast to southwest. The water ranges from soft to hard, generally contains iron and occasionally some salt and gas derived from bedrock, is obtained from

the drift at depths ranging from 25 to 100 feet; 65 to 75 feet being a common depth. The head ranges from 690 to 720 feet, falling off to the eastward about as rapidly as the surface slope, so that the water rises generally from 2 to 4 feet above the level, and has an average temperature of 51 to 53°F. Shallow wells, requiring pumping, are obtained from the sand and gravel deposits and occasional springs appear. Bedrock records are very meager because of the ease with which water may be obtained from the drift, rendering our knowledge of the nature of the bedrock and its depth incomplete. The NE.-SW. diagonal of the township seems to roughly separate the black (Antrim) shale to the southeast from the Coldwater series of sandstone, shale and limestone to the northwest. The depth ranges from 80 to 100 feet over an E.-W. central strip of the township, deepening to 130, or 140 feet, toward the SE. and NW. The actual elevation of the rock surface over this central strip is about 620 feet above sea level, dropping to 575 feet in sec. 4 and about 535 in sec. 36. The original forest growth was hard maple, beech, oak, whitewood, walnut and butternut over the morainic regions at the NW. corner of the township; over the flatter areas black ash, elm, whitewood, swamp oak, soft maple with some beech, basswood and wild cherry.

Springwells township. T. 2 S., R. XI E., (in part). Name alludes to the abundance of flowing wells. Original survey of boundary lines in 1816, and subdivisions in 1817, by Joseph Fletcher. Line between public lands and private claims run by same surveyor in 1822. Established 1827; contributed heavily to Greenfield township and Detroit, having but 9,830 square miles left; population 1835. Southern portion of the township taken up with French claims from the Rouge, determining the direction of most of the highways. The topography is unusually flat and even, sloping very gradually from an elevation of 610 feet, along the north boundary line, SE. to the level of the stagnant portion of the Rouge, about 574 feet. The drainage to the Rouge is sluggish and the streams largely intermittent. The soil is almost exclusively clay, of glacial origin over the western half of the township, but with few cobbles and boulders. The eastern half of the township has received a deposit of stratified clay which was deposited as a sediment in the waters of the series of glacial lakes. This sediment was derived, in large part, from the underlying till, separated from the sand and gravel by wave action, carried lakeward and deposited in the depression that lay to the westward of the Detroit moraine. The heaviest of this deposit, so extensively utilized in the manufacture of brick and tile, lies between Michigan Avenue

and the Michigan Central Ry. and eastward of the Pere Marquette Ry. From this as a center, it wedges out in all directions and mingles with the glacial clay. When quite wet and worked up by the wheels of vehicles, this type of clay gave almost impassable roads. Boulders are exceedingly rare in the deposit and to be explained as having been drifted in on icebergs floating in the glacial waters. The small "clay dogs," are of the nature of concretions and were formed where found, probably while the clay sediment was accumulating. The township was completely submerged by the glacial waters until the Elkton stage of Lake Lundy, when the extreme NE. corner began to emerge and a sand ridge was formed by the waves and given an E.-W. trend, just south of Holden Avenue and extending for a half mile upon either side of the Detroit, Lansing and Northern Ry. (elevation about 610 feet). During the first stage of Lake Rouge, with the water level at about 595 feet above sea level, a slight notch was cut in the clay, behind the Detroit moraine, very similar to that formed upon the opposite side by the correlative Lake St. Clair. This curves from West Detroit, around to Edward, just south of Michigan Avenue, takes a course slightly south of west across the township, curving southward across the SE. tip of Dearborn township into Ecorse. During this stage of the lake waters a little sand was spread over the clay in the immediate vicinity of Campbell Creek. Water, very rarely anything but hard, is obtained from two horizons and is generally abundant. The upper water stratum is reached at 12 to 30 feet; 15 to 18 feet, being a common depth. The deeper stratum ranges from 75 to 130 feet, approaching bedrock, furnishes a water with iron and sulphur and strong in chlorine, calcium and sulphates, temperature 51° to 53°F., under hydraulic pressure that brings it near, or above the surface, the maximum height reported being 20 feet. In a few instances, considerable salt is present, rendering the water unfit for use, and indicating its derivation from bedrock. The central portion of the township appears to be underlain by the limestone and blue shales ("soapstone") of the Traverse formation; the southern by the greyish limestone of the Dundee (Onondaga) and the northern by the black Antrim shales. The depth ranges from about 90 feet along the northern and southern margins to about 120 to 130 feet across the central portion of the township, indicating that there exists a shallow trough, entering from Dearborn and extending into Detroit. The rock surface in the northern part of the township has an elevation of 510 to 520 feet, dropping to 470 to 480 feet, and then rising along the Rouge to about 500 feet. The original

forest growth over the higher land was beech, hard maple, oak, whitewood, basswood and walnut; over the lower areas elm, black ash, soft maple and poplar.

Ecorse township. T. 2 to 3 S., R. X to XI E., (in part). Named from the Ecorse River, meaning *bark* in French. Made up largely of French claims. Established 1827; contributed to Taylor in 1847. Area 35.410 square miles; population (including Wyandotte) 9398. Although there is a margin of sand along the northern and eastern borders, the large part of the township is a flat, poorly drained till plain, with a stiff glacial clay soil, having only a small deposit of sedimentary clay from the series of glacial lakes that covered the region down to the birth of Lake Rouge. Surface boulders and cobbles are conspicuous only in the SE. corner, where the margin of the Grosse Isle moraine grazes the township. The western town line is remarkably level ranging in 6 miles only from 600 to 604 feet, above sea level, and the slope is gradual to the eastward, down to the river (574 feet), about 4 feet per mile, upon an average. The township is drained mainly by the three sluggish branches of Ecorse River and by short, intermittent tributaries of the Rouge. Both of these streams, as well as Monguagon Creek and the Huron River, show the phenomenon of "drowning," by which is meant that they have marshy banks and unexpectedly deep channels near their mouths, which were cut when Detroit River was practically out of commission and these streams had greater velocity because of their flow to a lower level. This cutting is believed to have occurred during the life of Lake Algonquin when the drainage was either by Chicago, or the Trent Valley in Ontario. The return to the St. Clair—Detroit outlet restored the former level and submerged the lower courses of these rivers. The original banks are still under water about their mouths and so little time has elapsed that they have not yet silted up their channels. Schools in the vicinity of these drowned areas should instruct their pupils as to these conditions since children in wading along the streams occasionally step off the submerged bank and are drowned. Ecorse township did not appear above the waters of the glacial lakes which followed the retreat of the ice from this region, until the level dropped from the Elkton stage of Lake Lundy to the first stage of Lake Rouge, when a poorly defined notch was cut in the glacial clay at an elevation of about 593 to 594 feet. This shore line enters sec. 31, SE. ¼, from Monguagon, curving to the northward through the eastern half of secs. 25 and 24, across the claims for a couple of miles and then veering slightly to westward and curving around

in the NW. corner of the township and across the SE. corner of Dearborn into Springwells township. Very little sand is deposited along its course and only a careful inspection of the flat country will enable one to detect the shore line, which must have been made with little wave action. In dropping from the first to the second stage, the distributary channels in the vicinity of Detroit and Windsor brought down considerable sand and this was worked into a rather well defined beach ridge along the eastern margin of the township, closely following the 580-foot contour.

Upon Brady Island, along its eastern margin, there is a pretty well defined gravel ridge at the right level for this beach. The gravel itself was probably deposited by the distributaries and subsequently modified by wave action. This gravel and sand ridge has obstructed the natural drainage, gives water at shallow depths and is indirectly responsible for much of the malaria and typhoid of the past. Good drainage for the country districts, sewers for Wyandotte and the villages and a closely guarded water supply are imperatively demanded. As is generally the case, getting water from the glacial clay is more or less uncertain, depths of 60 to 80 feet being common. A belt of flowing wells extends along the western margin of the township, the continuation of those from Monguagon, and although all have suffered loss of head and volume a number are still in commission. The water is generally charged with hydrogen sulphide gas (H_2S), often so much so as to be unfit for use. The depth to rock ranges from 70 to 90 feet over the township and so far as known it consists largely of the Dundee (Onondaga) limestone, seen in the Sibley quarry. At the northern end of the township (Oakwood) the elevation of the rock surface is 492 feet above sea level and at the southern margin some 510 to 520 feet, with no marked variation in range between.

Brownstown township. T. 4 to 5 S., R. X E., (in part). Named from Adam Brown, an early settler. Original survey by Joseph Fletcher in 1816 and 1817; established 1827. Reduced in 1842 to add to Monguagon. Area 40.005 square miles; population 2045. Entire township covered with the rectangular survey and only slightly interfered with by the French claims, ordinarily adopted along the main water courses. The highest elevation is in the NW. section (620 + feet), dropping to the SE. very gradually and deflecting the drainage to the Lake Erie level, 573 feet. The streams are of the young, consequent type, intermittent in their upper courses, straight, low banks, marshy, slightly branched. Smith Creek is peculiar in that it parallels the Huron for nearly its entire length and lies so near throughout. Those portions of the

streams below the 580-foot contour owe their position and direction of flow to the distributary channels and the depressions between the ridges of the Grosse Isle moraine. The general topography is flat and the soil is a stiff, glacial clay, as left by the Late Wisconsin ice sheet. For a distance of two miles west of Gibraltar and southward as far as the Huron gentle, parallel undulations of the Grosse Isle moraine are impressed upon the clay and the surface carries boulders and cobbles. These features constitute a waterlaid moraine, formed by an oscillating ice front, as it stood in some 200 feet of water of glacial Lake Maumee. The undulations are most conspicuous in secs. 27, 34 and 35 and grow fainter towards the Huron, giving out completely south of the river and seemingly continuing as a boulder belt. In the NW. corner of the township, some eight square miles of land were covered with sand during the Elkton stage of Lake Lundy, rather pronounced ridging occurring in secs. 9, 16 and 29, as the result of wave and subsequent wind action. The flat topography and clay subsoil have given rise to an extensive swamp in the north half of sec. 8, the southern half of 5 and NW. ¼ sec. 9. A swamp and marl deposit occurs in NE. ¼ sec. 28, the amount of marl not being ascertained. From Flat Rock to the mouth of the Huron there is more or less sand deposited along the northern side, or left bank. Some rather pronounced ridging occurs along the railroad (Detroit, Toledo and Ironton) and also just east of the Detroit and Toledo Shore Line at Rockwood, between 590 and 600 feet elevation. This sand was probably deposited by the Huron when the level of Lake Erie corresponded with that of the first stage of Lake Rouge, and was then modified by wave and wind action. A narrow belt of sand at the same approximate level crosses secs. 11 and 14 (Monguagon) just east of the center, diagonally across sec. 23 and continues southward through the western portions of secs. 26 and 35, then following the contour, jumps three miles westward to Flat Rock. There is very little indication along the lake and river shore of the stage of water corresponding to the second stage of lakes Rouge and St. Clair. Small patches of sand, or loamy soil do occur, however, in the neighborhood of the 580-foot contour (secs. 13, 23 and 24; T. 5 S.), and one mile west of Gibraltar (NW. ¼ NW. ¼ sec. 1) there occurs a short stretch of gravel beach, at the right level. The SE. point of Brownstown, largely submerged at this stage, received a veneering of black, mucky soil and is still largely swamp.

Water has ordinarily been obtained with great ease over the

greater portion of the township and flowing wells could be numbered by the hundred. However, a steady decline has been in progress and scarcely a one remains that reaches the actual level of the region in which it is located. A few still occur between Flat Rock and Rockwood that rise to the level of flats 3 to 5 feet below the general level, greatly reduced in quantity and head. This water was obtained in close proximity to the rock surface, either just on the rock, just above and a few feet within. The presence of iron and sulphur, along with chlorine, calcium and the sulphates, suggest that it has always come from bedrock. Over the southern half of the township some very heavy flows of similar spring water were common in an early day, but the flow from these has also been greatly reduced. Owing to the nearness of bedrock to the surface in the southern portion of the township (10 to 30 feet, as a rule) the wells are commonly shallow and some of them were reputed to be able to rise 10 to 20 feet above the surface. In the northern part of the township the bedrock lies from 70 to 80 feet below the surface and the wells generally go to this depth. The temperature of the water is very uniform, generally 51° to 52°F., but ranging from 50° to 55°. Over the sand covered regions limited quantities of fresh water are obtained at shallow depths, by reaching the clay. The loss of the flowing water is a serious one to many of the farmers, entailing considerable annual expense and it is hoped that this resource may still be properly conserved. The elevation of the surface of the bedrock ranges from 520 to 530 feet in the northern portion of the township to about 580 feet in sec. 35 (SW. ¼ SE. ¼) and about Flat Rock, dropping again some 15 to 20 feet toward the Huron. From the latitude of Rockwood southward, the glacial clay is underlain by the pure white Sylvania sandstone, extending nearly or quite to the mouth of the Huron. The distance down is but 12 to 18 feet, as a rule, and the sandrock is so incoherent that it often causes trouble in the wells. The middle third of the township is underlain by the dolomitic limestones making up the Upper Monroe formation and the high grade Anderdon limestone. The northern 3 tiers of sections must rest upon the Dundee limestone, exposed at Sibley and upon the Macon in Monroe County. The dolomites have been quarried for some years at the quarry W. NW. from Gibraltar (SW. ¼ SE. ¼ sec. 35) and reduced to road metal, but this plant was closed down and dismantled, Sept., 1911. It is noteworthy that the flowing wells come from each of the three formations represented, rather than any one, the strongest sulphur and iron waters being derived from the Upper Monroe. This

suggests that the water is conducted through joints and fissures into the neighboring strata and permits the hypothesis that the collecting area lies to the northwest, although this is the direction of dip for the rock strata. The native forest growth consisted, in the main, of white and black ash, hard and soft maple, yellow and white oak, hickory, elm, basswood, walnut, beech, whitewood, cottonwood and sycamore.

DELTA AREAS, FLAT SURFACES; SOIL GRAVELLY, SANDY LOAM.

Van Buren township. T. 3 S., R. VIII E. Named from President Martin Van Buren. Township lines surveyed in 1815 by Alexander Holmes; subdivisions by Joseph Wampler in 1819. Township established in 1835, derived from Huron; area 36.690 square miles; population 1700. Practically all except the NE. quarter of the township was strewn with delta deposits of gravel, sand and silt during the three stages of Lake Arkona, giving a smooth, flat topography, except for the occasional beach ridges. In the western part of the township the thickness of this deposit runs to 15 or 20 feet and where subsequently cut through by the Huron furnishes the conditions requisite for seepage springs along its banks. The gravel becomes finer and finer to the eastward and passes into sand, practically free from pebbles. Two-thirds of the deposits lie to the south of the Huron and appear to have deflected the river some five miles eastward before allowing it to take its natural southeast course to the lake. A small patch of glacial clay occurs just north of Belleville and secs. 2, 3, 10 and 11 have a similar soil, receiving but little of this delta dressing. The general surface slope is southeastward, average rate 7½ feet per mile, dropping from 720 feet to about 656. The Huron has deeply incised the country, the banks at Rawsonville being 55 to 60 feet high and diminishing slowly eastward. The township lies outside of the morainic areas but has a belt of boulders and cobbles, one to two miles broad, passing southward along the central meridian as far as Belleville, where it appears to turn westward to Rawsonville, entering Washtenaw County. This belt may be traced northward across the county and is believed by the writer to mark a temporary halt of the ice sheet, previous to the formation of the delta and incident to the final retreat from the region of the Late Wisconsin ice sheet. The three water levels of Lake Arkona are indicated by disconnected and often poorly defined gravelly-sand ridges, ranging in elevation from about 707 to 694 feet above sea level, having a generally southerly course and swinging to

the southwest. The upper Arkona ridge cuts across the southern half of sec. 18 to the eastern side and follows the section road north to Denton, passing through the western part of the village and furnishing a site for the cemetery. The middle ridge shows itself in the western part of sec. 30, was destroyed by the Huron, crosses sec. 17 and follows northward about a mile east of the highest Arkona as a faint feature, turns westward and crosses the Michigan Central Ry. near the center of sec. 5. The lowest ridge crosses the south half of sec. 31 and passes northward in secs. 32 and 29 until it encounters the old bank of the Huron that marks the Lake Warren stage. North of the river, it has faint expression across sec. 16, until it reaches the NE. ¼ when it deposited a little gravel upon the lakeward side of a prominent off-shore bar of the Middle Arkona stage, which curves northeastward across the NW. corner sec. 15 into sec. 10, passing northward through the western part and enters sec. 4 at its SE. corner, curving westward. These ridges, although generally of slight expression, are responsible for slack drainage and swampy soil in secs. 7, 8, 17 and 18. The advance of the ice front from a position some 25 miles NE. of Bad Axe to the vicinity of Port Huron caused the water level to rise to the Whittlesey beach in Washtenaw County and to flood the entire township, as it had been flooded by Lake Maumee during pre-Arkona times. No extensive delta formed at this stage, otherwise the Arkona beaches would have been buried and obliterated and when the water subsided to the Lake Wayne stage (elevation about 650 feet), the fall must have been rather rapid, otherwise the Arkona ridges would have been leveled. The Warren, or Forest beach (elevation 682) appears in the southern half of sec. 33, passes northward through the western part of sec. 28, reappears on the opposite side of the Huron in the northern portion of 22, is poorly represented in secs. 14 and 11, entering sec. 3 at its SE. corner and leaving from the NE. ¼ NW. ¼. Where the beach is not well shown cobbly areas occur as though the waves had removed some soil, leading to a concentration of these rock fragments. During the Warren stage the ice dam is believed to have been in the vicinity of Alpena, the drainage around the "thumb" into Grand River Valley, and thence into Lake Chicago, the advance of ice forcing the water to this level from that of Lake Wayne as previously noted in the Arkona-Whittlesey episode. The glacial water history for this region may thus be summarized: Lowest stage Lake Maumee (760 feet); Middle stage Lake Maumee (780 feet); three stages Lake Arkona, (705, 698, 692 feet); Lake Whittlesey (730 feet); Lake Wayne (650 feet); Lake

Warren (680 feet). The key to this peculiar behavior is furnished by the manner of ice retreat which seems to have consisted of a relatively long retreat each time followed by a short advance. During the Lake Warren stage, the Huron formed the terrace upon which the village of Belleville is situated the southern bank of the river, 10 to 12 feet high, cutting diagonally across sec. 30, southern half of 29, SW. ¼ sec. 29 and curving southward through the eastern half of sec. 33. The delta and beach deposits furnish a liberal supply of water at shallow depths, 7 to 30 feet, and numerous seepage springs, as noted, occur along the banks of the Huron and its tributaries. The water is generally hard, but sometimes medium and soft. In the clay areas, NE. ¼ of the township, it is necessary to go 50 to 125 feet, or even more, to get a supply; generally abundant, but sometimes meager. A splendid supply of flowing water (temperatures 51° to 52°F.) singularly soft, is obtained from the drift at Denton and two miles eastward by going from 70 to 80 feet in general, but occasionally from only 40 to 50 feet. According to George W. Lyons, driller, just over the rock lies a bed of "hard-pan," from one to ten feet thick, itself overlain by more or less gravel. The head of this water closely approaches 700 feet, dropping to eastward, indicating a source from the upland to the westward. The depth to bedrock varies from 80 to 90 feet at the NW. and SE. corners to about 120 feet at the center of the township, dropping then rapidly to the east and northeast. A very decided trough extends N. and S. through the eastern double strip of sections, some 170 to 180 feet deep, reaching its greatest depth at the SW. corner of sec. 1, where the rock elevation is about 495 feet, or 78 feet below the ordinary level of Lake Erie. The trough may have been gouged from the soft black shales by the action of the ice sheets, although its axis extends *across*, instead of *with* the direction of the main ice movements. The axis of the trough extends through secs. 12, 13 and 24, with elevation of 495 to 500 feet, rapidly rising some 40 to 50 feet. In the vicinity of Belleville, the shale rock ("slate") is reached at a depth of 99 to 118 feet, giving an elevation of the rock surface of some 560 to 580 feet above sea level, approximating Erie level. In passing to Denton it rises to about 620 feet, while toward the southeastward it remains approximately horizontal. A belt of black (Antrim) shale (sometimes mistaken for *coal*) underlies most of the township, passing from NE. to SW., and giving more or less gas. The Coldwater formation, consisting of light colored shale and sandstone, appears to cross the NW. corner, while the Traverse (limestone and "soapstone") crosses the SE. corner. The original

forest growth was hard and soft maple, white ash, beech, elm, white oak, whitewood, basswood, sycamore, hickory; with some red and swamp oak, black ash, butternut and walnut.

Livonia township. T. 1 S., R. IX E. Supposedly named from the province in Russia in an effort to find names not duplicated elsewhere. South and east township lines surveyed in 1816 by Joseph Fletcher; north and west lines in 1815 by Alexander Holmes; north line corrected in 1819 by Fletcher; township subdivided in 1816 by Fletcher. Established in 1835, derived from Nankin. Area 35.960 square miles; population 1365. This township shows the greatest variation of any in its physical features and soils and is crossed by the greatest number of the glacial lake beaches. The prevalence of considerable delta material, derived largely from the Middle Rouge during the Lake Arkona stages, as well as that brought down during this and other lake stages by minor streams, places Livonia in a class with Van Buren just described. The soil is very largely a gravelly, sandy loam, except for some ridges; sloping quite gradually from the Whittlesey beach (elevation 736 to 739), which cuts diagonally through secs. 5 and 7, southeastward to 634 (SW. cor. sec. 36), giving an average slope in this distance of some 16 feet to the mile. Westward of this well defined gravelly beach ridge the soil is a loamy clay, with some minor ridges of the Defiance moraine showing in secs. 5, 6 and 7 which were not obliterated by the waters of the glacial Lake Maumee. The drainage is mainly eastward by Bell Branch of the Upper Rouge, the southern portion of the township draining into the Lower Rouge. Bell Branch seems to be deflected eastward by the Rouge delta deposits to the southward, just as noted for the Huron in Van Buren, its southern branches being turned *northward* by the ridges of sand and gravel in sec. 21. Two boulder belts cross the township which probably mark the temporary positions of halt of the front of the Late Wisconsin ice in its retreat from west to east. The most westerly of these belts enters from the eastern part of Plymouth township, crossing secs. 18, 7, 8 and 5, heading towards Farmington. The second passes from N. to S. just east of the central meridian of the township, not especially well defined, and giving an indication of morainic topography in sec. 15. The bulk of the delta deposit was laid down in the SW. ¼ of the township, extending from eastern Plymouth, and reaches 12 to 15 feet in thickness, consisting of gravel and pebbly sand resting upon glacial clay, furnishing water to shallow wells and favorable conditions for seepage springs wherever the porous deposit is cut by the streams. A splendid flow of this nature is

found near the SW. corner of sec. 29; others in sec. 16 and vicinity. The gravelly sand and loam in the NW. ¼ and the northern half of the NE. ¼ is partly delta and partly shore material, from which shallow water is obtained with less certainty, often necessitating the sinking of wells to depths of 45 to 85 feet. Crossing the township in a general NE. to SW. direction there are 10, more or less distinct, beach ridges of either sand or gravel, or a mixture of the two. This series comprises all but the three youngest of the entire series of Huron-Erie beaches. The Upper Maumee cuts across the extreme NW. corner of sec. 7, entering from sec. 12 of Northville, and gives a sandy belt just above the 800-foot contour, upon both sides of the clay ridge crossing sec. 6. The Middle Maumee (3rd in age) lies ¼ mile to the eastward in sec. 7, where it shows fine development, approaches the higher in sec. 6 and lies just above the 780-foot contour. The Lowest Maumee enters sec. 7 (NW. ¼ SW. ¼) from the SW., just above the 760-foot contour, giving it a somewhat straight course to northeastward, except where destroyed by stream action, entering Oakland County very near the NE. corner sec. 6. In subsiding from the Middle Maumee stage, the waters fell to the Arkona stages, before returning to the Whittlesey beach already noted in secs. 5 and 7. The Upper Arkona is the best defined of the three in this region, lying just westward of the 700-foot contour. It enters the NW. ¼ sec. 30, passes northward through sec. 19 (being pushed eastward by the delta deposits) and then follows a very direct NE. course through secs. 18, 8, 5 and 4, parallel with the Whittlesey and about ¾ mile SE. of it. It is especially well developed in the northern half of sec. 4. Fragments of the Middle and Lowest Arkona are to be seen from ½ to ¾ mile to the eastward, separated rather poorly from one another and the next lower Warren beach; owing to the relatively rapid surface slope on the delta. The latter enters the SE. ¼ SE. ¼ sec. 31, curves northward through Nankin village, between secs. 29 and 30, gives some irregular ridging in sec. 20, crosses 17 diagonally, curves through the southern half of sec. 9, showing fine expression, crosses the NW. ¼ sec. 10 and leaves the county at the NE. ¼ NE. ¼ sec. 3. Quite a well defined gravel ridge appears in the NW. ¼ NE. ¼ sec. 32, at an elevation of about 670, crosses the eastern half of sec. 29, the western half of secs. 21 and 16, deflecting the drainage of the tributaries of Bell Branch. This ridge is too low for the Warren beach and too high for the Wayne, and may represent a bar in the former, or a hitherto unrecognized stage of the glacial waters, which left its record just here because of the abundance

of pebbles. Traces of the same stage are seen in sec. 10 (NW. ¼ SW. ¼ and NE. ¼ NE. ¼), and at the NW. ¼ NW. ¼ sec. 2. The Wayne beach is well defined in secs. 28 and 21, leading to the village of Livonia, but at an elevation some 7 to 8 feet too high (662 to 665 feet). Being a sand ridge this extra height may be accounted for as due to wind action. The ridge drops somewhat in sec. 15, but remaining about the 660-foot contour and flattens out to the northeastward. The Grassmere beach, representing the first stage of Lake Lundy, is indicated by some disconnected sand ridges in the SE. ¼ of the township, ranging in elevation from about 635 to 645 feet. The best defined and most continuous ridge begins in the NE. ¼ of sec. 27, curving into sec. 22, giving a branch to the northward and curving sharply to eastward across the southern half of secs. 23 and 24. Scraps of the same beach ridge occur northward on the town line in secs. 13 and 12, extending over from Redford. A limited area of flowing wells, with low head, occurs in the eastern part of sec. 18 and adjacent portion of 17; depth 45 to 55 feet; temperature 51° to 52°, somewhat soft. A "deer lick" is said to have been located on the flats at the NE. corner of sec. 7. In the SE. quarter of the township, where the delta deposit is thinner or entirely absent, it is necessary to enter the clay for water to depths of 60 to 100 feet or more, securing water reported as both hard and soft. The rock varies from 60 to 100 feet over most of the township, being more deeply buried in the NW. corner (110 to 120 feet) because of the rise in the surface levels. The elevation of much of the rock surface ranges from 550 to 580 feet above sea level, rising possibly 100 feet towards the NW. The NE.-SW. diagonal of the township approximately marks the line of separation between the Coldwater formation, of light colored shale and sandstone, and the black (Antrim) shale, carrying more or less gas. Penetrating this shale and entering the underlying Traverse, gives salt water and going still deeper into the Dundee limestone gave small quantities of a very thick black oil, serviceable as a lubricant (NE. ¼ NW. ¼ sec. 34 and SW. ¼ NW. ¼ sec. 36). The original forest growth was mainly elm, white and black ash, hard and soft maple, beech, oak and whitewood.

Dearborn township. T. 2 S., R. X E., (in part). Named from General Henry Dearborn. Township lines and rectangular subdivisions surveyed in 1816 by Joseph Fletcher; established 1833. The rectangular survey is rendered irregular by the military reservation about the village of Dearborn and the French claims along the Rouge and its northern branch. Area 34.410 square miles;

population 2761. Except where dissected by the three branches of the Rouge, the township is mainly level and flat, lying mostly between the contours of 600 and 630 feet. The NW. corner, however, rises to 639 feet and the SE. drops to 589, giving an extreme relief, aside from the river bottom, of 50 feet and a general southeasterly slope. The soil and subsoil are mainly a stiff glacial clay, relatively free from boulders and cobbles, which was formed beneath the Late Wisconsin ice, without any pronounced halt. Over the center of the township and towards the south and southeastward, the clay received a veneering of sand during the Elkton stage of Lake Lundy, some prominent ridges being formed as the result of wave and subsequent wind action. These dune ridges, some of them rising to 620 feet, have furnished sites for the irregular, diagonal roads leading from the village of Dearborn. This sand was brought to the lake very probably by the Rouge and originally deposited as delta sand, afterwards being worked shoreward by the waves. From secs. 4 and 5 southward to 32 and 33 there occurs a veneering of sand up to 8, 10 and 12 feet in thickness, with only very minor ridging, lying between the contours of 615 to 625 feet, which probably represents, in part, a delta deposit of the earlier stage of Lake Lundy, somewhat modified by wind. The three branches of the Rouge: Upper, Middle and Lower, enter the township with banks varying in height from 20 to 30 feet, and with average fall of 8 feet per mile, measured from the Whittlesey beach along their respective valleys. Within the limits of the township the banks become lower and the fall becomes much less, for the main Rouge amounting to less than 6 inches per mile. With these three streams converging and flowing so much below the general level, the surface drainage is good. Over the sandy portions of the township, water is obtained from shallow wells (10 to 25 feet) by entering the clay far enough to obtain a suitable reservoir. The water thus obtained is not usually very abundant, is generally hard, but occasionally soft. In the clay districts obtaining water is uncertain both as to amount and depth. In the eastern part of the township the water rises to near the surface, under artesian pressure, but does not flow. A heavy flow of sulphur water was struck in the village of Dearborn, depth 290 feet, showing a head of 635 to 640 feet. This water probably comes from a channel in the Monroe formation, instead of from a single water bearing stratum, and even neighboring wells might yield no such flow. The depth to rock ranges from 60 to 80 feet in the northern tier of sections, deepens from 120 to 140 feet across the central strip, and rises southward from 80 to 100 feet again

in the vicinity of sec. 34. The village of Dearborn lies over the axis of a shallow trough in the rock surface, which enters from southern Nankin and extends across Springwells, spreading out beneath Detroit. The elevation of the bottom of the trough seems to range from 500 to 470 feet above sea level as it crosses the township from west to east. Toward the north, the rock surface rises from 550 to 560 feet and southward from 525 to 535 feet. The bedrock is probably very largely the Traverse formation, consisting of alternating layers of limestone and bluish shale ("soapstone"). The records of gas found in the wells along the northern border of the township along with the adjacent region suggest that this portion is underlain by the black (Antrim) shale. Upon the sand areas the main forest growth was originally black and white oak, black and white ash, elm, basswood, butternut, and chestnut, with some hard and soft maple and beech. The clay supported in the main a growth of elm, black ash, oak, beech, hard and soft maple, basswood and hickory with some walnut.

BEACH AND DUNE AREAS; HEAVY RIDGING AND SANDY SOILS.

Sumpter township. T. 4 S., R. VIII E. Named from Gen. Thomas Sumter. Township lines surveyed by Alexander Holmes in 1815; subdivisions in 1819 by Joseph Francis; reserve by James H. Mullett in 1843. Township established in 1840, derived from Huron and for a time called "West Huron." Area 37.285 square miles; population 1228. The northern half of this township extends into the delta formation of the Huron, during the Arkona stage, and geologically belongs with the preceding main division of townships, being covered with a pebbly sandy loam. This deposit is highest and presumably thickest towards the NW. corner of the township (elevation 692 feet), thinning towards the east, southeast and south; the pebbles becoming finer and finer and passing into sand. The general slope is southeastward, dropping to 626 feet at the SE. corner, or at the average rate (neglecting the sand ridges) of about 8 feet to the mile. The NE. and SW. corners of the township are almost exactly the same level, if we neglect the valley of the Huron, which there grazes sec. 1. The drainage is either into Swan Creek direct, or into its tributary Disbrow Ditch. The westernmost portion reaches Stony Creek and the extreme northern strip is drained into the Huron, the upper courses of the streams being largely intermittent. The township is crossed from NE. to SW. by the beaches of three of the series of glacial lakes, the lower two of which (the Wayne

and Grassmere) show considerable wave and subsequent wind action, the ridges formed being distributed largely along the southern and eastern strips of sections. These ridges are sharply defined, generally less than a mile long, irregularly placed and extend in no uniform direction. Since some of them may be of the nature of bars and others of dunes, it is difficult to separate the two sets from one another. The slack drainage caused by these sand accumulations is responsible for a rather extensive swamp in sec. 29, which extends southward into sec. 32. Numerous deposits of ochre ("bog iron ore") in the central and western sections indicate that the swamps were more extensive formerly than at present. The Warren, or Forest beach, is not well defined, consisting of a faint, gravelly sand ridge, just above the 680-foot contour. It cuts across the northern half of sec. 7 to the NE. corner, curves across the southern half of sec. 5 and cuts the NW. ¼ of sec. 4, entering Van Buren township. Some little clay soil and loam are found in secs. 25, 26, 35 and 36. Throughout the gravel and sand areas shallow wells (6 to 16 feet) yield a supply, generally sufficient, of water variously reported as hard, soft and medium. Sometimes all that is necessary is to dig or drive to the vicinity of the underlying clay; when greater supplies are desired, a reservoir in the clay is made into which the water collects from the overlying sand and gravel. In the SE. quarter, where the sand is largely concentrated into ridges, it is necessary to enter the clay to depths ranging from 30 to 70 feet, in some cases water being obtained from a stratum of gravel just over bedrock. Water somewhat sulphury, and rising under artesian head to near surface. In 1903 one flowing well existed at the SW. ¼ SE. ¼ sec. 25. The rock ranges in depth from 35 feet at the SE. corner of the township to about 100 feet at the NW. corner, so far as may be judged from the meager records. The actual elevation of the rock surface does not vary greatly from 560 to 580 feet above sea level. The underlying rock of the SE. half is probably Dundee limestone, similar to that seen on the Macon, Monroe County, and at Sibley; the NW. half is probably the limestone and bluish shale ("soapstone") of the Traverse formation, which is liable to yield water more or less charged with salt. The original forest growth corresponded very largely with that of Van Buren over the northern area and much scrub oak over the heavily sanded areas, along with some chestnut.

Huron township. T. 4 S., R. IX E. Named from the river which received its name from the tribe of Indians that occupied the region. West township line surveyed in 1815 by Alexander

Holmes; north, east and south lines in 1816 by Joseph Fletcher; subdivisions in 1816 by Fletcher. Township established in 1827 and later reduced to form Van Buren (1835), Romulus (1835), and Sumpter (1840). While the latter was known as "West Huron," this township was known as "East Huron." Area 35.790 square miles; population 1690. The township as a whole is characterized by sandy soil, the western half carrying numerous, irregularly placed sand ridges; the NE. ¼ carries an even dressing of sand without ridging; the SE. ¼ contains minor knolls and ridges of sand, considerable loam and some clay. Isolated patches of clay and loam occur also in the other quarters of the township. The general slope of the township is from NW. to SE. (about 650 to 600 feet), or at the average rate of about six feet to the mile, neglecting the ridges. Between the SW. and NE. corners of the township there is slight difference in elevation. The Huron crosses the township diagonally and receives most of the drainage, through short, largely intermittent streams. The banks are dropping to the eastward, being about 34 feet above the bed at New Boston and 20 to 22 feet at Flat Rock. The SW. corner of the township is crossed by one branch of Swan Creek and receives drainage from a few sections. In spite of the sand covering, a belt of boulders and cobbles ("Scofield boulder belt") may be traced from N. to S. along the Pere Marquette Ry., believed by the writer to mark a stage of halt of the ice sheet in its final retreat across the township. The ice front at this time may then have served as a dam for the waters of Lake Maumee during one of its temporary stages. The further retreat of the ice to the NE. allowed the glacial waters to drop to successively lower levels and the township began to emerge during the first stage of Lake Lundy, when the waves threw up the ridges across the NW. corner of the township (elevation about 635 feet). The sands upon drying were heaped still higher by the wind and scattered over the clay surface. In secs. 7 and 18 some of the ridges are high enough to have been formed during the preceding Lake Wayne stage, rising about 650. In the vicinity of Willow and Waltz the strongest of the sand ridges have a NW.-SE. trend, from 615 to 625 feet in elevation, and were apparently formed by wave and wind action during the Elkton stage of Lake Lundy. The shore line extended NE. through secs. 22, 23, 24 and 13, but made no definite ridge. Two sets of wells are used; the shallow (7 to 20 feet) from the sand deposits and the deeper wells into the clay, ranging ordinarily from 30 to 85 feet, and in some cases entering rock. The former wells are hard to soft, the latter yield water with some sulphur.

The depth to rock ranges from about 20 feet in the neighborhood of Flat Rock, to 80 to 90 feet in the NW. corner. The actual elevation of the rock surface is about 580 feet above sea level, near Flat Rock, dropping from 10 to 20 feet only towards the northwest and not varying greatly from horizontality. The well records give limestone only for the bedrock, not distinguishing between the real limestone and the dolomitic variety. The SE. portion of the township must, however, be underlain by the Upper Monroe dolomites, with their strong sulphur waters and the northwestern portion by the Dundee limestone, with its occasional suggestion of oil. The test well at the NE. ¼ of sec. 17 proved a disappointment. The township consisted largely of the "oak openings" of pioneer days.

Romulus township. T. 3 S., R. IX E. Named presumably from the reputed founder of Rome. West township line surveyed in 1815 by Alexander Holmes; north, east and south township lines by Joseph Fletcher in 1816; subdivisions by Fletcher in 1817. Township established in 1835, being derived from Huron. Area 35.660 square miles; population 1538. Romulus township is closely related to Huron just described so far as soils, topography and geological history are concerned. It, however, contains much more clay and loam over its eastern half; flat and poorly drained by intermittent streams giving an easterly or southeasterly course to the Ecorse and Brownstown Creek. The Scofield boulder belt enters from Huron township at about sec. 32 and takes a N. NE. course across the center of the township, leaving at sec. 3, marking a position of halt of the ice front. The belt is about 1½ miles broad and contains boulders and cobbles, especially abundant in the northern half of the township. Neglecting the sand ridges the general slope is to the southeastward, from an elevation of approximately 670 feet to 620 feet, or about six feet to the mile as in Huron township. The NE. corner of the township is about 25 feet lower than the SW., the latter having been built up by delta material from the Huron, during the glacial lake series of the Arkona and Warren stages. A set of sand ridges between secs. 29 and 30 may be traced northward through the western part of the village of Romulus (sec. 17), veering NE. into secs. 9 and 4, and ranging from 655 feet to 670 in elevation. These ridges were apparently formed by the waves of Lake Wayne and then heaped up by wind into dunes. A second set of similarly formed dunes marks the first stage of Lake Lundy, some 25 to 30 feet lower. They cut through the southern half of secs. 31, 32 and 33 and then beginning in the SW. ¼ sec. 34 form a peculiar series of

approximately parallel NW.-SE. ridges as far as the eastern margin of the village of Romulus and determining the course of the diagonal road through secs. 34, 33, 28 and 21. From Romulus NE. the ridging is less well defined but may be seen in secs. 10, 11, 12, 1 and 2, separated by areas of clay and loam, suggesting weaker wave action than that in the SW. ¼ of the township. The SE. ¼ of the township was submerged but the water was only 10 to 15 feet deep and received some sprinkling of sand over much of the clay. The slack drainage to the westward of these heavy ridges was responsible for swamp conditions in the past in which muck soil was formed. Such a deposit lies between secs. 5, 6, 7 and 8, the muck sometimes taking fire and burning to a depth of 6 to 8 feet. The sand of the NW. portion of the township is slightly pebbly, suggesting that the ancient delta of the Huron may extend this far east and north. Most of the wells are of the shallow, sand type, 8 to 20 feet, furnishing limited quantities of hard, medium and soft water. When the quantity is insufficient, deeper wells are sunk and this is invariably demanded in the clay and loam areas, and where the sand is too thin to furnish water in quantity. The wells of this character range, in general, from 40 to 80 feet and the water is more or less impregnated with iron or sulphur, especially when obtained from near bedrock. In 1903 only one flowing well existed in the township, NW. ¼ NW. ¼ sec. 36; depth 48 feet to "hard pan." The bedrock is buried by 60 to 140 feet of clay, gravel and sand, deepening from SE. to NW., the actual elevation not differing greatly from 520 to 560 feet above sea level. The SE. corner is probably underlain by the Dundee limestone, which gives traces of gas and oil in a few wells; the remainder of the township has the Traverse formation for its foundation, consisting of limestone and shale ("soapstone"), the water from which gives some salt. The deep well put down upon the Twark farm (SE. ¼ NW. ¼ sec. 12) reached rock salt at a depth of 925 feet and penetrated successive layers of salt and lime to a depth of 1820 feet.

Taylor township. T. 3 S., R. X E., (in part). Named from Gen. Zachary Taylor. Township lines and subdivisions surveyed in 1816 and 1817 by Joseph Fletcher. Established in 1847, being derived from Ecorse. Area 23.825 square miles; population 1238. The township is flat and sand covered in large part, receiving its deposits during the life of Lake Lundy, both stages. Isolated patches of clay and loam occur and a strip of stiff glacial clay extends along the very flat eastern boundary, which ranges in elevation from 600 to 604 feet in the six miles. This clay area is

part of the till plain which covers the greater portion of Ecorse township. The western boundary ranges from 620 to 630 feet, the slope being eastward and averaging from 5 to 7 feet to the mile. The northern half of the township is drained eastward into the Ecorse, the southern half by three drains, somewhat south of east, into Brownstown Creek. A set of short, disconnected sand ridges passes from N. to S. through the center of the township, lying mainly eastward of the central meridian, and formed during the Elkton stage of Lake Lundy, at an elevation of 610 to 620+ feet. The N. to S. road through secs. 16 and 21 was evidently shifted ¼ mile west of its proper position in order to get the advantage of this sand belt. Some ridging occurs in the eastern part of secs. 20 and 17 and runs through the northern part of secs. 8 and 9. The sand along the western strip of sections may represent blown sand from the Elkton shore and also that deposited in the shallow waters of the first stage of Lake Lundy. The sand areas, especially where deepest, yield water at depths of 7 to 20 feet, ranging from hard to soft, and often sufficient for farm purposes. The clay wells range from 60 to 100 feet, yielding water charged with some iron and sulphur, under artesian pressure. In 1903 flowing wells were found at the SW. ¼ SW. ¼ sec. 34; SW. ¼ SW. ¼ sec. 28; NE. ¼ NE. ¼ sec. 15; NE. ¼ NE. ¼ sec. 10; belonging to the belt of flowing wells passing northward from Brownstown and Monguagon, through Ecorse. The depth to rock ranges from 60 feet at the SW. corner to 90 feet at the NW., the shallower having a surface elevation of about 550, the deeper an elevation of about 535 feet above sea level. At the SE. corner, the rock surface drops to about 620 feet. From all the information available, the bedrock is largely limestone of the Dundee (Onondaga) formation, similar to that seen at Sibley. The Traverse probably crosses the NW. corner giving alternating limestone and shale ("soapstone"). The water from it is not highly charged with either salt or sulphur. After penetrating the limestone, the Upper Monroe dolomites are reached which invariably yield water highly mineralized and charged with sulphur.

Nankin township. T. 2 S., R. IX E. Named from city of China. Township lines surveyed in 1815 by Alexander Holmes and Joseph Fletcher; subdivided in 1816 by Fletcher. Established in 1829; derived from "Bucklin" and originally included Livonia. Area 35.940 square miles; population 3966. The eastern and southeastern portion of the township extends into the flat till plain type of topography, with soil of loam or glacial clay, upon which have been superposed some minor ridges of sand, as the result of wave

and wind action. The NW. corner of the township extends into the delta region of the Middle Rouge (Arkona and Warren stages) and is coated with a pebbly sand, similar to that described for Livonia to the northward. Between these two areas extends a broad belt, 3 to 4 miles broad, from NE. to SW., of heavy sand, more or less ridged, especially along the eastern margin of the belt. The general slope of the township is from NW. to SE., dropping from about 693 to 626 feet, above sea level, or at an average rate of about 8 feet to the mile. The NE. corner of the township is about 28 feet lower than the SW. corner (667-639 feet). The drainage is eastward (Middle and Lower Rouge) the streams being more or less deflected by the sand accumulations. The Scofield boulder belt, one to two miles broad, crosses the middle of the township, from N. to S., lying mainly to the eastward of the middle meridian. Many of these boulders and cobbles have been collected and utilized in foundations. During the Maumee, Whittlesey and two higher Arkona stages, the township was completely submerged by the glacial waters. When the level had fallen to the lowest Arkona stage, a poorly defined sand ridge was built across the NW. ¼ of sec. 6, at an elevation of about 693 or 4 feet above sea level. An advance of the ice front is then believed to have forced the water to the middle stage of Lake Arkona, raising it some 7 to 8 feet. At the time of its next recession, a drop to about the level of 650 feet occurred and the broad sandy beach of Lake Wayne was formed with elevation of 655 to 650 feet, except where wind blown to greater height. Ridging occurred north and northeastward of the village of Wayne in secs. 28, 27, 22 and 23, reaching northward into 14, 15 and 10, marking the approximate shore line of the lake waters. During this stage the lake extended around the "thumb," the ice dam being some 25 to 30 miles NE. of Bad Axe, but the drainage is believed to have been into the Mohawk, near Syracuse, N. Y. An advance of the ice front, until it again covered the tip of the "thumb," forced the water up some 30 feet to the level of Lake Warren, and the drainage was shifted to the Pewamo, Ionia and Grand River valleys into Lake Chicago. This increased elevation brought the level to about 680 feet, extending across the NW. ¼ of sec. 6, very near the Lowest Arkona, but without leaving a very definite record. The sand found along the N.-S. road between secs. 5 and 6, 7 and 8, may represent bar deposits in Lake Warren, or possibly a temporary shore line corresponding to that observed northward in Livonia township at this same approximate level. In subsiding from the Warren stage, during which time the Wayne

beaches were submerged, the water dropped to the Lundy stage and made a series of sand ridges in secs. 35, 26 and 25, extending to the village of Inkster and reappearing again in secs. 1 and 2. The most of the sand ranges in elevation from 635 to 640 feet, above sea level, but some of it was heaped into still higher dunes by wind action. The slack drainage caused by the sand deposits is responsible for an extensive swamp, involving some 160 acres, but originally much more extensive, in the vicinity of the SE. ¼ of sec. 18, extending into secs. 17, 19 and 20. The sand that mantles the clay attains a thickness of 10 to 12 feet and shallow wells are the rule over the western half of the township. These yield sufficient water, as a rule, which ranges from hard to soft. About the center of the township and over much of the eastern half, where the sand is scantier, it is necessary to enter the clay and to varying depths (40 to 140 feet), securing water which carries some salt and sulphur. In the SW. corner of the township, the artesian pressure is sufficient to bring the water very near or quite to the surface causing flows to the west and northwest of Wayne. Upon the old Proctor Estate also, a well has been flowing (NW. ¼ NW. ¼ sec. 15) for a number of years. The depth to bedrock is about 100 feet at the SE. corner and about 125 feet at the NW. corner, with a trough-like depression of 120 to 160 feet cutting across the southern half of the township. Just south of Perrinville the well records indicate that the rock rises to 50 feet, forming a rock knoll on the northern side of the depression and attaining an elevation of about 585 feet. Just west of Inkster the rock surface in the trough-like depression referred to drops to about 480 feet above sea level, this being a part of the same feature which enters from Van Buren and extends into Dearborn, probably representing an old pre-glacial drainage valley, modified by ice action. The rock elevation at the extreme SE. corner is about 520 feet, and about 560 feet at the NW. corner. The bulk of the township appears to be underlain with the black (Antrim) shales ("slate"), which give more or less gas when entered. The SE. corner is probably the Traverse formation of limestone and light colored shale ("soapstone"), which generally yields water containing some salt. The original forest growth was white, yellow and black oak and whitewood, some chestnut, over the "oak openings;" beech, elm, hard and soft maple, ash, basswood on the lower land; some hickory and walnut on the flats.

Redford township. T. 1 S. R. X E. Named from the ford of the "Rouge," original name being Pekin. Township lines and sub-

divisions surveyed in 1816 by Joseph Fletcher. Established in 1829, being derived from "Bucklin" township. Area 35.680 square miles; population 2176. Although almost all of the SE. ¼ of the township is clay soil, of the flat till plain type, the bulk of it is strewn with sand, much ridged in parts, which places it geologically with the preceding townships of this division. Even over the sand region, isolated patches of clay and loam make their appearance. Neglecting the ridges of largely wind-blown sand, the general slope of the township is southward, dropping from the highest elevation 668, on the Base Line, sec. 1, to about 618, near the center of the southern boundary line; or at the average rate of about 8 feet to the mile. The SW. corner is 39 feet lower (668-639) than the NE. corner, and the SE. corner lies 30 feet lower (651-621) than the NW. corner, while the drop near the middle of the township from N. to S. is 37 feet (659-622), or about 6 feet to the mile. The surface drainage is entirely into the Upper Rouge, by means of short, more or less intermittent tributaries. The rise of land in the NE. corner of the township is due to the crossing there of the Detroit moraine, which runs from Birmingham to Detroit and was formed *sub-glacially* between the Erie and Huron lobes of the Late Wisconsin ice sheet. This feature deflects the drainage to the SW., the average slope amounting to about 9 feet to the mile in the NE. ¼ of the township. Although morainic, the surface was very smooth and received a surface dressing of sand during the three stages of the two glacial lakes, Wayne and Lundy. The shore lines, beach ridges, bars and dunes of the two can not be clearly separated although with the help of the contour map the most prominent may be identified. The older of the two lakes (Wayne) was responsible for the ridging seen in secs. 1, 2, 11 and 12 and for a gravelly soil; the result of wave action on the till, seen about the SW. corner of sec. 12. The heavy sand ridges in the vicinity of Sand Hill, as well as those to the west and south, with a general N. to S. trend, are to be referred to the Lake Lundy, first stage. The sand was in part washed directly from the till, and in part delivered to the lake by the Upper Rouge, the mouth of which was in the vicinity of the present village of Redford. The waves of this lake built up ridges to a height of 635 to 640 feet. The most prominent of these dunes are seen in secs. 7, 8, 9, 10, 11, 15, 16, 20, 21 and 29. As a further result of wave and wind action, a dressing of sand was spread over the general surface of the country obliterating most of the glacial clay. This general deposit reaches a thickness in places of 10 to 12 feet and furnishes well water at shallow depths (10 to 20 feet), the water

ranging from hard to soft, insufficient to abundant. Where the soil is clay or loam, and where the sand deposit is thin, it is necessary to enter the glacial deposit known as till and depths of 25 to 80 feet are required to obtain a sufficient supply. This water is often charged with gas and mineral ingredients (sulphur, salt, etc.) from the underlying bedrock, although it may be derived from beds of gravel and sand. The rock itself must sometimes be entered a few feet especially in the SE. ¼ of the township in order to insure a sufficient quantity. These deeper wells furnish water under artesian pressure in all cases, rising to near the surface but not actually flowing. The depth to bedrock ranges from 80 to 100 feet over the township and, although some of the well records indicate differently, the bedrock is very probably nearly all black shale (Antrim formation), which so commonly yields temporary flows of gas, often under great pressure when first struck. The salt reported in some of the wells in the southern portion of the township, in which direction the shale thins out, is probably derived from the underlying Traverse. The elevation of the rock surface at the SE. corner is not far from 550 feet above sea level; rising slightly towards the NW. The original forest growth was beech, hard and soft maple, black and white ash, elm, walnut, hickory, oak and basswood.

Greenfield township. T. 1 S., R. XI E. Name alludes to the appearance of the fields. Township lines surveyed in 1816 by Joseph Fletcher; subdivisions in 1817 by Fletcher. The SE. quarter of the township includes the "Ten thousand acre tract," surveyed in 1816 by Fletcher and sold to provide the territory with a courthouse and jail. Established in 1833, being derived from Springwells. Area 34.782 square miles; population 4995. Although much of the southern third of the township is glacial clay or loam, the bulk of the township is veneered with sand, much of which has been heaped into conspicuous ridges. The clay is of the till plain type and practically free from surface boulders. From NW. to SE. the township is crossed by the broad, smooth swell of clay which constitutes the Detroit moraine. The highest elevation noted is at the NW. corner (668 feet above sea level) and following along the axis of the moraine drops to about 630, at the SE. corner, or at an average rate of 4¾ feet to the mile. The slope to the NE. and SW. from the axis of the moraine is considerably more rapid, deflecting the drainage accordingly by many, short intermittent streams, those to the south of the moraine going to the Rouge; those to the north to Conners Creek, the moraine serving as the divide. Just upon the crest the drainage is slack and an

extensive marsh enters sec. 5, from 32 of Royal Oak township (Oakland County), extending into sec. 4. Along the western town line the descent is from 668, at the NW. corner to about 618, at the SW. corner, 50 feet in the 6½ miles, or at the average rate of nearly 8 feet to the mile. The higher land caused by this morainic extension across the township formed a broad peninsula during the Lake Wayne and Lake Lundy stages of the glacial lakes, before which time the township was submerged and after which it was dry land. The first of these lakes threw up a series of beach and bar ridges, from the tip of the peninsula in sec. 20, around on the eastern margin through secs. 21, 10, 9 and 4, at elevations ranging from 655 to 665 feet, above sea level. The westernmost two of these approximately parallel ridges may be traced rather continuously for some 4 to 5 miles, the lower and outer is more scrappy and irregular, curving through the SE. ¼ of sec. 20 and across the western half of 21 into sec. 10. As the water rose from the level of Lake Wayne to that of Warren, owing to an advance of the ice front, these beaches and the NW. ¼ of the township were again submerged and the crest of the moraine here strewn with sand, which is slightly pebbly in places. The level of the lake waters subsequently fell to that of Lake Lundy, first stage, and formed a complicated set of irregular ridges in the vicinity of Palmer Park, at elevations ranging from 635 to 645 feet. A sand ridge of this stage, some two miles in length, crosses Woodward Avenue in Highland Park, between Highland and Glendale avenues. Irregular ridging and small amounts of gravel occur to the southwest between Woodward and Grand River, as in SE. ¼ sec. 28; SW. ¼ sec. 28; SE. ¼ sec. 29; westward through sec. 30. In receding from the first stage to the second, or Elkton stage, a somewhat poorly defined and disconnected sand ridge was formed at an elevation of about 610 to 612 feet, extending eastward through the southern margin of sec. 31 and the northern portions of secs. 5, 4 and 3 of T. 2 S., R. XI E. As in the case of the other townships of this class, the sand strewn portions yield water at shallow depths (6 to 18 feet), which ranges from hard to soft, is sometimes sufficiently abundant, at other times scanty in amount. In entering the clay for water, depths ranging from 25 to 135 feet are required, approaching the bedrock. In general, this water is hard but, at times, surprisingly soft; abundant as a rule, but sometimes the head is insufficient to bring the water to the surface, rising usually from 12 to 20 feet of the ground level. When the bedrock is entered, gas often accompanies the water, along with more or less sulphur and iron. By entering

the deeper strata, the water is generally impregnated with salt. The bedrock underlying the greater portion of the township is undoubtedly the black (Antrim) shale. Across the SE. corner there is probably a narrow strip of the limestone and shale which constitute the Traverse formation. This rock ranges in depth from 80 to 140 feet, being greatest along the east township line and least towards the SW. corner, where the elevation of the rock surface rises from 520 to 530 feet, as compared with about 500 feet at the SE. corner. The original forest growth was black ash, basswood, elm, oak, soft maple, beech, hickory, some walnut, hard maple, whitewood and sycamore.

Hamtramck township. T. 1 S., R. XII E., (in part). Named from Col. John Francis Hamtramck. Township lines and subdivisions surveyed in 1816 by Joseph Fletcher. Contributed to Grosse Point, Gratiot and city of Detroit. Area 16.888 square miles; population 7122. The southern half of the township is rendered irregular by the French claims along Conners Creek, the "Park lots" and "Ten thousand acre tract," lying to the eastward of Woodward Avenue. Passing from Warren township (Oakland County), there extends southward across the township the obscure, waterlaid Mt. Clemens moraine, formed at the ice front of the Huron lobe, during one of the Lake Maumee stages, while the water had a depth of 140 to 160 feet. A little ridging of the clay may be seen in the NE. ¼ of sec. 4 and a few cobbles and boulders southward towards Detroit, but in the main the morainic features and glacial clay are disguised by a covering of beach and dune sands formed about the margin of the glacial Lake Lundy, first stage (elevation 630 to 640 above sea level). This sand is much more abundant over the northern half of the township, the southern portion being mostly clay and loam. The elevations over the township are quite uniform, ranging from about 620 to 640 feet, the crests of the dunes alone reaching the latter height. These ridges are arranged with very little regularity, being short, straight, or curved, irregularly placed and orientated, but with a tendency to a NE.-SW. trend. The land was not high enough to receive any of the Lake Wayne beach, nor low enough for the second, or Elkton stage, of Lake Lundy. The sand deposits supply water at shallow depths which ranges from hard to soft and varies considerably in amount. The water may be obtained directly from the sand, or by forming a reservoir in the clay and allowing the water from the sand to seep in. When this is insufficient in amount, the clay must be entered until a water bearing stratum of sand or gravel is reached. This requires depths ranging from 10 feet

to bedrock, which may reach 180 feet. When so obtained the water is generally hard and abundant and, except in the quite shallow wells, only slightly affected by seasonal variations. In entering the rock (limestone or shale), water is obtained often charged with gas, sulphur or salt. In a few instances it is surprisingly soft. In all the deeper wells the water rises under artesian head and may come to within 4 to 5 feet of the surface, but nowhere flows, within the limits of the township. The bedrock is deeply buried by the so-called "drift," ranging from 140 to 160 feet in the western part of sec. 5, where there appears to be a decided depression in the rock surface, the elevation of which is approximately 450 feet above sea level, rising to about 480 feet along the southern township line. The original forest growth was oak, elm, soft maple, black ash, basswood, sycamore and some beech.

CHAPTER X.

PRELIMINARY REPORT ON THE FAUNA OF THE DUNDEE LIMESTONE OF SOUTHERN MICHIGAN.

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INTRODUCTORY.

From the collections so far made, about 80 species of invertebrates have been identified. This is by no means a complete list of the species of this fauna; there is a considerable number of species still unidentified, on account of their fragmentary character, while future collections will undoubtedly increase the total number.

In the present report, the species are discussed briefly;* their illustration and full description with discussion of variations and relationships will appear in the monograph on the Traverse fauna of Michigan, which is in preparation, since these fossils are intimately related to those of the other Middle Devonic beds of Michigan. In the monograph, the "Dundee" of Northern Michigan will also be discussed. Much of the details, therefore, on which the present report is based is here omitted, but will be included in the final discussion.

SUMMARY OF THE FAUNA.

The order of arrangement of the classes and genera is that followed in Grabau and Shimer's North American Index Fossils.

INVERTEBRATA.

Class I. PROTOZOA.

None have been recorded from the Michigan beds so far, though in the closely related Columbus limestone of Ohio, *Calcisphaera robusta* Williamson is abundantly represented, often making up

*For descriptions and illustrations of the common forms, see Grabau and Shimer, North American Index Fossils, 2 vols. This report was submitted in 1910. Since then further study has shown that some of the species listed herein are new, but since it is not possible to give at present a complete revision, it is thought best to publish this preliminary report as written. The full discussion of the Michigan Devonic faunas will appear in due time.

masses of the rock. This fossil closely resembles the organs of fructification of the freshwater stonewort, or Chara, with which it is sometimes identified. It is a nearly spherical body 1 mm. in diameter, and banded by nine spiral ridges.

Class II. PORIFERA.

This class is likewise unknown, so far, in the Dundee of Michigan, but in the Columbus limestone of Ohio it is represented by *Receptaculites devonicus* Whitfield. (Pal. Ohio VII., pl. VI., fig. 10).

Class III. HYDROZOA.

Division HYDROCORALLINES.

This division, represented by a number of genera and species in the Columbus limestone of Northern Ohio, is more sparingly represented in the Dundee of Southern Michigan. From the collections so far made, the genus *Clathrodictyon* has alone been identified. This is represented by a species closely related to, if not identical with, *Clathrodictyon cellulosum* Nicholson and Murie, characterized by the coarseness of its meshwork, and common in the Onondaga limestone of Canada, and occasionally occurring in New York.

In Ohio, the following species have been recorded from the Columbus limestone:

Actinostroma nodulatum (Nicholson).
Stylodictyon columnare Nicholson.
Stromatopora granulosa Nicholson.
S. ponderosa Nicholson.
S. sanduskyensis Rominger.
S. substriatella Nicholson.
S. (Syringostroma) densa Nicholson.

Class IV. ANTHOZOA (Corals).

This class is fairly well represented in some parts of the Dundee, though it is not known to form reefs, such as are characteristic of the Onondaga of Western New York and of the Jeffersonville limestone of the Falls of the Ohio. As will be shown later, the horizon of the Dundee is probably above that of the coral reefs of the Onondaga, a fact further emphasized by the marked dissimilarity of the coral faunas of the two regions. The species so far obtained from the Dundee of Southern Michigan are as follows:

Genus ZAPHRENTIS Rafinesque.

Zaphrentis convoluta Hall.

This appears to be the most abundantly represented form in Southern Michigan. It is a rapidly expanding curved cone showing the tetrameral arrangement of the septa by the septal striae on the outside of the coral, and characterized by uniting and more or less twisting septa. The fossula is scarcely indicated, though in a few cases, it is discernable. The species is close to Streptelasma. It has been found in the Sibley quarry in beds: A. (6 ft. bed), B. (7 ft. bed), D. (5 ft. bed), E. (6 ft. limestone), I. (9 ft. bed) and elsewhere.

Zaphrentis prolifica Billings.

This species is similar to the preceding, and when the calyx is filled by matrix, can scarcely be distinguished from it. The septa are less strongly twisted, often scarcely at all, and the fossula is well developed. This probably occurs with the preceding, though none of the specimens in the collections I have examined appear to conform to it; but it has been reported from the Dundee of Southern Michigan. It is not uncommon in the lower Traverse of Northern Michigan.

Zaphrentis gigantea Lesueur.

This large species, characteristic of the Onondaga of Western New York and of the Falls of the Ohio, has been reported from the Dundee of Michigan and the Columbus of Ohio. Its cylindrical growth, large size, well developed tabulae which bend down marginally, and well marked fossula are distinctive characteristics. At present, no specimens of this species are contained in the collections of Dundee limestone fossils.

Zaphrentis corniculum E. and H.

This has been recorded from the Dundee of Michigan and the Columbus of Ohio.

Other species of Zaphrentis obtained from the Columbus limestone of Ohio are: *Z. edwardsi* Nichols and *Z. wortheni* Mich.

Genus AULACOPHYLLUM E. and H.

Aulacophyllum sulcatum E. and H.

This species, common in the Jeffersonville limestone of the Falls of the Ohio and also found in the Hamilton group, is sparingly represented in the Dundee of Southern Michigan. It is characterized by the converging septa on either side of the well developed cardinal fossula, in which a thin cardinal septum occurs. The species also occurs in the Columbus limestone of Ohio.

Genus CYSTIPHYLLUM Lonsdale.

Cystiphyllum vesiculosum Goldfuss.

This species is represented mostly by medium-sized individuals, most of the specimens collected being much worn. The cysts are large and the form moderately tapering. No specimens of the size of the prevailing Hamilton form have been found so far.

The species is common in the Onondaga of New York, Canada, and the Falls of the Ohio. It occurs in the Columbus limestone of Ohio, where another, smaller species, with fine cysts, *C. ohioense* Nicholson, also occurs. The latter species has not yet been found in Michigan.

In the Dundee of Southern Michigan, *C. vesiculosum* has been found in the Sibley quarry in Bed A (6 ft. bed), B (7 ft. bed), D (5 ft. bed), I (9 ft. bed) and above, as well as in some of the other horizons.

Genus ACERVULARIA Schweigger.

Acervularia rugosa E. and H. (*Cyathophyllum rugosum*).

This species is not uncommon in the Dundee of Southern Michigan. It has been obtained from 15 to 20 ft. above the bottom of the Sibley quarry in bed I (9 ft. bed) and in bed A (6 ft. bed). It has also been found more generally distributed.

This species occurs in the Sellersburg (Hamilton) limestone of the Falls of the Ohio and in the Columbus limestone of Ohio. It has not been reported from any horizon in Western New York. The species seems to be represented in the Traverse of Northern Michigan, where *Acervularia davidsoni* is the common reef coral. The separation of Acervularia from Cyathophyllum, merely on the ground of the possession of an inner wall is ill advised, since Acervularia has no true inner wall. It seems likely, with our present knowledge, that both *Cyathophyllum rugosum* and *Acervularia davidsoni* belong to Acervularia, and that they are closely related.

Acervularia davidsoni is a characteristic Hamilton species of Michigan, Iowa, and westward. The genus as such seems foreign to the true Onondaga fauna, and the occurrence of *A. rugosa* in the Dundee and Columbus seems to argue for a post-Onondaga age of these formations. This idea is borne out by the fact that the species occurs in post-Onondaga beds (Sellersburg or Lower Hamilton) at the Falls of the Ohio. The origin of the genus seems to be a western one.

Genus PHILLIPSASTRAEA d'Orbigny.

Phillipsastraea gigas Owen.

This species with calices 20 mm. in diameter has been reported from the Dundee of Michigan, but seems to be confined to the northern area. No specimens have been observed in our collections. It is also a typical Hamilton species in Michigan, Ohio, and the Falls of the Ohio, but in New York and Canada it seems to be confined to the Onondaga.

P. verneuilli E. and H.

This form, with smaller corallites, (10 to 15 mm. in diameter), has been reported from the Onondaga of Canada and the Dundee of Michigan, but appears also to be confined to the northern Dundee. It is likewise reported from the Hamilton of Thedford, Ontario, but this identification needs verification.

Genus ERIDOPHYLLUM E. and H.

Eridophyllum verneuillianum E. and H.

This form occurs in the Columbus limestone of Ohio, and will probably be found in the Dundee of Southern Michigan. I have not seen it among the collections.

E. colligatum (Billings) has been reported from Northern Michigan, and occurs in the Jeffersonville of the Falls of the Ohio and the Onondaga of Canada.

Genus SYNAPTOPHYLLUM Simpson.

This genus differs from the preceding in the absence of the central wall, but agrees with it in the connections between corallites.

Synaptophyllum simcoense Billings.

A small part of a colony of this species has been obtained from the Sibley quarry. It is not abundant but characteristic. The diameter of the corallites is about 4 or 5 mm. It occurs in the Columbus limestone of Ohio, the Onondaga of Canada and Western New York, the Jeffersonville of the Falls of the Ohio, and the "Dundee" or Mackinac limestone of Northern Michigan.

Genus FAVOSITES Lamarck.

Favosites emmonsi Rominger.

This species, with tubes 1 to 1½ mm. in diameter, and crowded tabulae seems to be represented in the Dundee of the Sibley quarry. It is not an abundant form, but is most characteristic of the Onondaga of Western New York and Canada. In Ohio, it occurs both in the Columbus and the Delaware. At Louisville, Ky., it is found in the Jeffersonville beds, and in Northern Michigan in the Mackinac limestone. It has also been recorded from Iowa.

Favosites turbinatus Billings.

This species is the most abundant of any in the Dundee of Southern Michigan. It is of turbinate form, curved, and resembles in outline some Cyathophylloid coral or the mold of some large pelecypod shell. The tabulae of our specimens are rather distant, as are also the mural pores.

The species occurs pretty generally distributed through the Dundee of the Sibley quarry. It has been collected from Bed I (9 ft. bed) and from the 12 ft. bed above the lower 20 ft. bed.

This species is found in the Onondaga of Canada and New York, and in the Columbus of Ohio. It is, however, more distinctively a Hamilton type, occurring in that formation in New York, Ohio, Louisville (Falls of the Ohio), Thedford, Ont., and the Traverse of Michigan.

Other species of Favosites found in the Columbus limestone of Ohio are: *F. basaltica* Goldfuss; *F. hemispherica* Yand. and Shum.; *F. invaginata* Nich.; *F. pleurodictyoides* Nich.; and *F. polymorpha* Goldf. *F. hemispherica* also extends into the Hamilton.

Genus CLADOPORA.

Cladopora cryptodens (Billings) (?)

This is a round-stemmed, branching species, the branching being chiefly a bifurcation. The branches are from 5 to 10 mm. in diameter, and the corallites are scarcely curved. Tabulae few and incomplete. The identification of our specimens with Billings' species is provisional. The specimens are all broken, showing the corallites but not their orifices. They were found in Bed I (9 ft. bed) and in the 12 ft. of beds above the lower 20 ft.; also in the upper 5 ft. of the lower 20 ft.

The species is widely distributed, occurring in the Onondaga of Canada, New York, the Falls of the Ohio, and in the Mackinac limestone of Northern Michigan. Many other species have been obtained from the Mackinac limestone, but no other from the Dundee or Columbus.

The following table shows the distribution elsewhere of the corals obtained from the Dundee of Michigan and the Columbus of Ohio.

TABLE LXV.—SUMMARY OF THE CORAL FAUNA.

	Dundee of Michigan.	Columbus of Ohio.	Jeffersonville of Kentucky.	Onondaga of New York.	Onondaga of Ontario.	Mackinac Limestone.	Sellersburg of Kentucky.	Hamilton of New York.	Hamilton of Thedford, Ont.	Hamilton of Ohio.	Traverse Group of Michigan.	Mid-Devonic of Iowa.
1. *Zaphrentis convoluta*	×	×	×		×	×	?		×		?	
2. *Z. prolifica*	×		×						×	×		
3. *Z. cornicula*			×									
4. *Z. edwardsi*			×	×	×	×		×				×
5. *Z. gigantea*			×									
6. *Z. wortheni*			×	×								
7. *Aulacophyllum sulcatum*	×		×		×	×	×	×	×	×	×	×
8. *Cystiphyllum vesiculosum*			×	×						×		
9. *C. ohioense*			×									
10. *Hadrophyllum d'orbignyi*			×			×				×		
11. *Cyathophyllum zenkeri*			×									
12. *C. robustum*			×	×								
13. *Heliophyllum halli*			×					×	×		×	×
14. *H. confluens*			×					×			?	
15. *Acervularia rugosa*	×		×					×	×			×
16. *A. davidsoni*	?		×									
17. *Stylastraea annae*						×						
18. *Phillipsastraea gigas*						×						
19. *P. verneuilli*			×									
20. *Eridophyllum verneuillianum*			×			×						
21. *E. strictum*			×			×						
22. *E. colligatum*			×	×		×						
23. *E. simcoense*	×		×		×	×				×		
24. *Aulopora cornuta*			×			×						
25. *A. filiformis*			×						×	×		×
26. *A. tubiformis*			×			×						
27. *Syringopora hisingeri*			×	×		×						
28. *S. maclurii*			×									
29. *S. tabulata*			×									
30. *Favosites basaltica*			×								×	?
31. *F. hemispherica*			×	×	×	×						×
32. *F. invaginata*			×									
33. *F. pleurodictyoides*			×									
34. *F. polymorpha*			×									
35. *F. turbinata*	×	×	×		×	×		×	×	×	×	
36. *F. emmonsi*			×	×								×
37. *F. limitaris*			×			×						
38. *Michelina convexa*			×	×								
39. *M. maxima*			×									
40. *M. cylindrica*			×									
41. *Cladopora cf. cryptodens*	×		×			×						
42. *Alveolites squamosus*			×					×	×	×	×	×
43. *Trachypora elegantula*			×									

A study of this table which is based on the best available data, shows some interesting results. Of the 43 species listed, 8, or 18.6 per cent., are known elsewhere only from the Hamilton beds; while 10, or a little over 23 per cent., are elsewhere in the eastern province known only from the Onondaga. One of these, however, *Aulacophyllum sulcatum*, is found also in the post-Onondaga beds of Iowa. The other Onondaga species include, moreover, some of the most characteristic species of Eridophyllum, Synaptophyllum, Syringopora, Michelinia, Cladopora, and Alveolites. On the other hand, it should be noted that it is just these species that are sparingly represented in Ohio; and that only two of them, *Synaptophyllum simcoense* and *Cladopora cryptodens*, occur in the Dundee of Michigan, the first represented by one small specimen, the other doubtfully identified. Moreover, it is these species which may still be found among the coral fauna of the Traverse Group when the study of it is completed, and too much weight should therefore not be placed on this apparent preponderance of Onondaga types. Among exclusively Hamilton species, such characteristic species as *Heliophyllum halli, Heliophyllum confluens, Aulopora tubaeformis*, and *Trachypora elegantula* occur. Of other species generally most characteristic of the Hamilton fauna occur: *Zaphrentis prolifica, Heliophyllum halli, Acervularia rugosa;* and, doubtfully, *A. davidsoni, Favosites hemispherica, F. turbinata,* and *F. limitaris.* On the other hand, species more characteristic of the Onondaga fauna are: *Zaphrentis gigantea, Phillipsastraea gigas, P. verneuilli;* various species of Eridophyllum, Synaptophyllum, and Syringopora; and *Favosites emmonsi.* All of these, however, have been found in typical Hamilton strata. Such typical Onondaga species as *Favosites epidermatus, F. canadensis, Cystiphyllum sulcatum, Acrophyllum oncidaense, Amplexus yandelli, Chonophyllum magnificum*, etc., are wanting. While not conclusive, the evidence of the coral fauna points to a higher horizon than typical Onondaga for the Columbus of Ohio and the Dundee of Michigan, and its closer affiliation with the Hamilton of the eastern province.

Class V. BRYOZOA.

Bryozoa are common in the Dundee of Michigan, some parts of the coarser limestones (calcarenites) abounding in fragments of Fenestella and others. Owing to their fragmentary character, only a few have been identified so far.

Genus FENESTELLA Lonsdale.

Various species of this genus seem to be represented among the fragments, including, apparently, *F. (Semicoscinium) planidorsatum* Ulrich, also found in the Sellersburg of the Falls of the Ohio.

Genus CYSTODICTYA Ulrich.

Cystodictya gilberti (Meek).

This species, originally described from the Columbus limestone of Ohio, and abundant in that horizon as well as in the overlying

Delaware, is very common in the Dundee of Southern Michigan, occurring in nearly all the outcrops. It is readily recognized by its flat, repeatedly branching stems, and the rapidly increasing number of rows of apertures and separating ridges. The species occurs in the Hamilton (Sellersburg) of the Falls of the Ohio and of Indiana.

SUMMARY OF THE BRYOZOA FAUNA. So far as studied, the Bryozoa indicate a closer relationship of the Columbus and Dundee to the Hamilton than to the true Onondaga. The most abundant and most typical species, *Cystodictya gilberti,* is elsewhere found only in the Hamilton.

Class VI. BRACHIOPODA.

Genus STROPHEODONTA Hall.

Stropheodonta inaequiradiata Hall.

This typical Onondaga species is represented by a few individuals from the Sibley quarry. It is recognized by its coarse, unequal striae and moderate convexity of the pedicle valve. It occurs in the Columbus of Ohio and is known from the Onondaga of New York and Quebec, and appears to be represented in the Devonic of Nevada.

Stropheodonta dundeense sp. nov.

This species is extremely convex, of the average size of *S. demissa,* but with the striae crowded, and often fasciculate. It resembles somewhat a diminutive *S. hemispherica,* but its convexity is too great for it to represent the young of that species. From *S. inaequiradiata* it differs in its greater convexity, and in the more crowded condition of its striae. It is not unlike some of the extreme forms of Stropheodonta from the Hamilton of Missouri. In the Sibley quarry, this species is most abundant in beds G (6 ft. bed) and I (9 ft. bed), and again in the 12 feet of the strata above the lower 20 feet.

Stropheodonta hemispherica Hall.

This large, convex Stropheodonta is abundant in the Dundee of Southern Michigan. Often it is extremely convex and large, but there are many small or half grown individuals. The brachial valves are very gently concave in the younger part, and then become

abruptly bent or even geniculate. The striae are sometimes fasciculate, but not sharp, as in *S. demissa*. The median septum of the brachial valve and the cardinal septum are well marked. The pedicle valve is uniformly and strongly convex, often with a median ridge-like accentuation, and sometimes with rude irregular folds in addition. It occurs throughout the series of strata in the Sibley quarry, and has been noted in the other outcrops, and in the equivalent beds near Windsor, Ontario, as well as in the Columbus of Ohio. Elsewhere this species occurs in the Schoharie and Onondaga formations, having been found in New York, Ontario, etc.

Stropheodonta concava Hall.

This species seems to be represented by a number of specimens with the characteristic sharp striae and the strongly muscular impressions of this Hamilton species. It is found in several of the beds in the Sibley quarry (Bed G, and the bottom 20 ft. bed), and occurs also in the Columbus limestone of Ohio. In New York, it is chiefly confined to the Hamilton, where it abounds, though it has been reported also from the Onondaga. In Indiana it occurs in the Sellersburg and Jeffersonville.

Stropheodonta costata Owen.

This species, probably the *S. erratica* of Winchell, is represented by a few individuals easily recognizable by their small size and coarse plications. It is an abundant form in the Lower Traverse beds of Northern Michigan.

Stropheodonta fissciosta Winchell.

This species is another typical Traverse form in which formation it abounds. A single specimen has been obtained from the Dundee of the Sibley quarry. It is readily recognized by its divided costae, otherwise resembling the preceding. A closely related species is figured by Kindle from the Jeffersonville of the Falls of the Ohio, as *S. plicata* Hall.

Stropheodonta demissa (Conrad).

This characteristic Hamilton species is represented by a considerable number of specimens which show the typical form and bundled striae. They occur in coarse calcarenyte scattered through the section. A variety somewhat less convex than the normal form, and with a shorter hinge line with more rounded ends also occurs

in the lower beds. On the whole, the specimens resemble more closely those found in the lower shales of the Traverse beds to the north, than the coarser striated New York form.

The species is recorded from the Onondaga of New York, but the individuals are small and not typical. Those from the Dundee and the Columbus resemble more the Hamilton type than the variety from the Onondaga. The species is widely distributed in the Hamilton of North America.

Stropheodonta alpenensis sp. nov.

This species is the most abundant of any in the Traverse Group of Michigan, occurring throughout, with several modifications. It is about half the size of *S. demissa*, and looks not unlike a dwarfed representation of that species. Its uniform size, together with its ornamentation, however, show it to be distinct.

The species is not uncommon in the Dundee of Michigan, the specimens from this horizon agreeing in all respects with those from the Traverse Group. They often become very robust, and this is also true of the Traverse species. In such cases, the muscular impressions become strongly marked. This species probably occurs in the Columbus limestone of Ohio, as well as in the Dundee of Western Ontario.

Stropheodonta (*Leptostrophia*) *perplana* (Conrad).

This species is not uncommon in the Dundee of Southern Michigan, and the Columbus of Ohio. It is readily recognized by its flat character and the fine radiating striae. Not infrequently, concentric undulations, recalling the characters of *Leptaena rhomboidalis* occur, especially on the younger individuals.

The species is rather generally distributed through the formations. Its range elsewhere is from the Schoharie to the Chemung.

Stropheodonta (*Pholidostrophia*) *iowaënsis* (Owen).

(*Stropheodonta nacrea* Hall).

This characteristic Hamilton species is abundantly represented in the Dundee of Southern Michigan and the Columbus of Ohio. The limestone specimens rarely show the nacreous lustre observed in the specimens of the shales, but the characteristic form and absence of striae permit ready identification. Though reported from the Onondaga, it is most typical of the Hamilton in all the exposures of the latter from New York to Iowa. It occurs in the Sellersburg and Jeffersonville of Indiana.

Stropheodonta pattersoni Hall.

This Onondaga species is reported from the Columbus limestone of Ohio. Its convexity, extended hinge line with deflected angles, and distant striae alternating with finer ones, characterize the species. Some of the other limestone species might be mistaken for this, and there is some possibility that the identification is not absolute. In any case, it has not been found in the material from Michigan.

Genus STROPHONELLA Hall.

Strophonella ampla Hall.

This large, reversed form, with the pedicle valve convex in the young, but strongly concave in the adult, has been found in the Columbus limestone of Ohio, but has not yet been reported from Southern Michigan. It is a characteristic Onondaga species in New York and Ontario.

Genus LEPTAENA Dalman.

Leptaena rhomboidalis (Wilckins).

This widespread species is represented so far by a single specimen in the Dundee of Michigan, but appears to be more abundant in the Columbus limestone of Ohio. Its concentric wrinkles and sudden rectangular anterior deflections are sufficiently distinctive features. Its great range (Trenton to Waverly) makes it of little value as a horizon marker.

Genus SCHUCHERTELLA Girty.

(ORTHOTHETES of most authors.)

Schuchertella arctostriata Hall.

This species, with its irregular form, long hinge line, and alternating striae, seems to be well represented in the Dundee of Southern Michigan, where it occurs at several horizons. It has not been reported from Ohio, but is common in the Hamilton of New York, Ontario, and occurs in the Jeffersonville of Indiana, etc.

Schuchertella pandora Billings.

This Onondaga species occurs in the Columbus limestone of Ohio, and may also be represented in the Dundee of Michigan. Its

regular form, fine, sharp striae, strong curvature, and straight beak distinguish it. It is characteristic of the Onondaga of New York, Ontario, and elsewhere, and has been reported from the Devonic of Nevada.

Schuchertella (Orthothetes) flabellum Whitfield.

This small, strongly plicate species was described from the Columbus limestone of Ohio. It is unlike any other known Devonic form, but one from the Upper Monroe of Michigan agrees quite closely with this. Since Monroe species have before been described as Onondaga types, the horizon of this species should be verified. It occurs in the Sibley quarry, and also in the upper 100 feet of the Detroit shaft.

Genus CHONETES. Fischer de Waldheim.

Chonetes mucronatus Hall.

This is the most abundant and characteristic species of Chonetes in the Dundee of Southern Michigan. It is of medium size, with deflected cardinal angles, and with finer striae than is usual for this species in the Onondaga limestone of New York, etc. In this respect, the species agrees entirely with the specimens from the Marcellus shale of New York, the number of striae approximating 24-26. The spines are long, slender, and parallel to the hinge line. Altogether, the mutation of this species here presented agrees so closely with the Marcellus types as to lead to the supposition that they were contemporaneous, and that the species was *eurylithic*, or capable of occupying a wide range of bottom facies, i.e., from calcareous sand and mud to highly carbonaceous muds unsuited to most forms of organisms. The range of this species as a whole is rather wide, beginning in the Oriskany and continuing into the Hamilton. The various mutations, however, seem to be restricted to narrow stratigraphic zones.

In the Dundee of Southern Michigan, it is most abundant in the chert beds A and H (6 ft. and 2 ft. beds), and the chert bed over the 9 ft. bed. It is also found in the limestones at various levels in the Sibley quarry and in the upper layers penetrated by the salt shaft at Oakville, Detroit. It is also found in the Columbus of Ohio, and in the same rock in the region about Windsor, Ont. It occurs in the Sellersburg and Jeffersonville of Indiana, etc.

Chonetes gibbosa Hall.

This species is represented by a single specimen obtained from the lower beds of the Sibley quarry. It is very convex, with more numerous striae than in *C. mucronatus,* and with strong spines bent outward. The species elsewhere occurs in the Hamilton.

Chonetes deflecta Hall.

This species, with the convexity and general characters of *C. mucronatus,* but with much finer striae, more strongly deflected cardinal extremities, and rather more oblique spines, also occurs in the limestones of the Sibley quarry, and in the Columbus limestone of Northern Ohio. It is essentially a Hamilton species.

Other species recorded from the Columbus limestone of Ohio are: *C. acutiradiata* Hall, *C. arcuata* Hall, and *C. yandellana* Hall. Elsewhere these species are distributed as follows: *C. acutiradiata* from the Onondaga of New York, and the Jeffersonville of the Falls of Ohio, *C. arcuata* from the Onondaga of New York and *C. yandellana* from the Jeffersonville of the Falls of Ohio.

Genus STROPHALOSIA King.

Strophalosia truncata Hall.

This characteristic Marcellus species seems to be common in certain of the beds in the Dundee of Southern Michigan, especially the chert beds. The pedicle valve is convex, with a strong umbonal truncation, and with spinous ridges running for some distance and ending in spines of moderate length. The range of this species is from the Marcellus to the Portage, but it has not been reported from any lower horizon. It has so far remained unrecorded from the Columbus limestone of Ohio.

Genus PRODUCTELLA Hall.

Productella spinulicosta Hall.

This species is not uncommon in the limestones, where it is strongly convex, with rather strong spinous ridges and long spines. Some of the specimens have the character of *P. shumardiana* of the Onondaga limestone, these occurring in the upper beds of the Sibley quarry. The typical forms occur in the 2 ft. chert bed (Bed H) and in the chert bed above the 9 ft. bed. It is also found in other non-cherty beds of the quarry. Elsewhere it is most characteristic

of the Hamilton beds, though it has been recorded from the Onondaga.

Genus RHIPIDOMELLA Oehlert.

Rhipidomella variabilis sp. nov.

This is the commonest species of the Dundee limestone. It is transverse, varying in proportional height and width, approaching on the one hand *R. vanuxemi*, and on the other *R. penelope*. The pedicle valve varies from convex to nearly flat, while the brachial valve is strongly arched. Generally a well-marked, broad, but ill-defined sinus occurs toward the front of the pedicle valve, and a flattening, rarely a depression, in the brachial valve. The muscular impressions are like those of *R. vanuxemi*.

This species seems to have been the stock from which *R. vanuxemi*, *R. penelope*, and *R. livia* were derived, the various mutations leaning towards one or another. Some specimens are scarcely distinguishable from *R. penelope*, except that they do not reach the size of that species.

The young of typical *R. vanuxemi* is proportionately broader than the adult, a feature characteristic of the adult of *R. variabilis*, which, therefore, fulfills the requirements of an ancestral form in this respect.

The common form of this species is distinguished by its breadth and its median pedicle sinus. Some of the specimens approach *Schizophoria propinqua* in outline, but the hinge is always shorter and the muscular impressions are distinctive. The species is pretty generally present in the various beds of the Sibley quarry. It also occurs in other exposures of this formation in Southern Michigan and the adjoining Canadian region. It is found also in the Columbus limestone of Ohio.

Rhipidomella vanuxemi Hall.

This characteristic Hamilton species appears to be represented by a number of individuals from the Dundee of Southern Michigan. In this horizon, it has more the value of a fluctuating variety, but becomes well fixed in the succeeding Hamilton. It has been reported from the Onondaga, but its chief development is in the Hamilton of New York, etc. The species is also reported from the Columbus limestone of Northern Ohio.

Rhipidomella penelope Hall.

Several of the mutations of *R. variabilis* are sufficiently modified and increased in size so that they may virtually be regarded as *R. penelope*. The distribution seems general. Elsewhere this species is known only from the Hamilton.

R. livia Billings.

This species has been reported from the Columbus limestone of Ohio, and appears to be likewise represented from the Dundee of Southern Michigan. It occurs elsewhere in the Onondaga, as in Ontario. It is doubtfully reported from the Sellersburg of Indiana.

Genus SCHIZOPHORIA King.

Schizophoria iowaensis Hall.

This form is not uncommon in the Dundee limestone. It is large, robust, and very convex in the brachial valve, which bears a well marked median depression towards the front. The muscular impressions are small and deep. The species, on the whole, agrees most closely with the commoner forms of the Traverse Group, though some approach *S. propinqua* Hall. It is also found in the Columbus limestone and in the Onondaga of New York, etc. This species is especially abundant in Bed I (9 ft. bed) and in the beds above the lower 20 ft. of the Sibley quarry.

Genus PENTAMERELLA Hall.

Pentamerella arata Conrad.

This species has been recorded from the Columbus of Ohio, but the specimens are not typical, as are those of the Schoharie and Onondaga of New York. It is not definitely known from the Dundee of Michigan, though a fragmental specimen suggests its possible presence.

Pentamerella cf. pavilionensis Hall.

This species seems to be represented by a brachial valve having the characteristic form and plication. It was obtained above the 9 ft. bed. The species is a widely distributed Hamilton form.

Genus CAMAROTOECHIA Hall and Clarke.

This genus is represented by several species not fully identified. In the Columbus limestone occur *C. dotis* Hall, *C. billingsi* Hall, *C. carolina* Hall, and *C. thetis* Billings. The first of these is a Marcellus and Hamilton form; of the others *C. billingsi* occurs in the Onondaga of New York and Canada, *C. carolina* at the Falls of the Ohio, and *C. thetis* in the Onondaga of New York, the Sellersburg and the Jeffersonville of the Falls of the Ohio and the Devonic of Nevada.

Genus TROPIDOLEPTUS Hall.

Tropidoleptus carinatus Conrad.

This characteristic and diagnostic Hamilton species of Eastern North America has been reported from the Columbus limestone of Ohio. It has not been noticed in the Dundee, but it may prove to be present. If correctly identified, it furnishes a further link in the relationship of these strata to those of New York; for this species has, in North America, been found only in the Marcellus and Hamilton, though also occurring higher up.

Genus ATRYPA Dalman.

Atrypa reticularis Linnaeus.

This species is abundantly represented by normal individuals. It is also common in the mutation *elegans*, mut. nov., which is always small, but becomes very robust, often approaching a globular form. The muscular impressions are strongly marked, and the surface feature comprise fine, uniform striae, repeatedly bifurcating and crossed by very distant, strong, concentric lines, which produce a slight nodosity at the crossing. Repeated bifurcation of the striae keeps them fine and greatly increases their number.

The pedicle valve is rather more strongly convex than in the normal form, and in outline it is often somewhat elongate. Sometimes there is a faint flattening down the middle of the brachial valve, giving this form some resemblance to *A. impressa* of the Schoharie.

The species occurs in the chert bed and in the limestones of the quarry. It has also been reported from the Columbus limestone of Ohio.

Atrypa spinosa Hall.

This species is abundantly represented, being more numerous than the preceding. It has moderately coarse plications, which, in some cases, are seen to continue as tubular spines beyond the edge of the shell. In some forms, the plications are few and coarse, with strong concentric lines, as in the typical Hamilton specimens. The number of primary plications is not over 8 or 10, and they increase by repeated division. This species ranges pretty nearly throughout the limestone. It has not been recorded from the Columbus of Ohio, and elsewhere it is chiefly confined to the Hamilton, though it is said to range up into the Chemung. It occurs in the Sellersburg of the Falls of the Ohio and Charlestown, Ind.

Genus CYRTINA Davidson.

Cyrtina hamiltonensis Hall.

This characteristic Hamilton species is also represented in the Dundee of Southern Michigan and the Columbus limestone of Ohio. It is typical, with moderately curved hinge area, and occurs in beds I and J of the Sibley quarry, as well as in the upper 100 feet penetrated by the Detroit salt shaft. The variety *recta*, with straight hinge area, is also represented. Though reported to range from the Onondaga to the Portage, this species is most typically represented in the Hamilton, where it is a diagnostic fossil. Both occur in the Sellersburg and Jeffersonville of the Falls of the Ohio.

Genus SPIRIFER Sowerby.

Spirifer bidorsalis Winchell.

This is a small species characteristic of some of the lower beds of the Traverse Group of the Traverse Bay region. It is elongate, with a moderate hinge area, rounded, strong plications, about 9 on each side of the sinus, and a low plication in the sinus. The fold is divided by a sharp median groove. In the specimens from the Traverse shales, strong concentric striations occur, but, in the specimens from the limestone, these are seldom visible. The species is scattered through the upper layers in the Sibley quarry. A variety occurs which is larger proportionally, and more robust, and has fewer plications. This variety is found also in the Columbus of Ohio.

Spirifer gregarius Clapp.

This species seems to be represented by several small individuals with rather weak plications. They are strongly convex and have a profound median sinus and strongly overarching beak of the pedicle valve. They are smaller than the normal forms from the Onondaga of New York and the Sellersburg and Jeffersonville of the Falls of the Ohio, and seem to be confined to the upper beds in the quarry. The form occurs in the Columbus limestone.

Spirifer grieri Hall.

This species is readily recognized by the plications on the fold and sinus. It is represented by a number of individuals, the distribution of which through the beds of the Sibley quarry and the upper part of the Detroit salt shaft show it to be a rather common form. It is also found in the Columbus limestone and in the Onondaga of New York and the Jeffersonville of the Falls of the Ohio.

Spirifer manni Hall.

This species, originally described from the Columbus limestone of Ohio, is common in the Dundee of Southern Michigan. It is generally elongate, with moderate area, and a marked flattening or median depression on the fold of the brachial valve. Genetically it appears to be closely related to *S. johnsoni* Grabau Mss. of the Lower Traverse, the only difference being in the faint lateral plications in the sinus of *S. johnsoni*. Through the last named species, this species is related to *S. oweni*, which is approached by some accelerated individuals of *S. manni* in form, but the plications of the sinus are scarcely developed. Once in a while, the faint plications are formed, so that the specimens may be referred either to *S. johnsoni* or to *S. oweni*. This is the common Spirifer of the Dundee, occurring more or less abundantly throughout the series.

S. manni occurs in the Columbus limestone, and in the Onondaga of Western New York and the Jeffersonville of the Falls of the Ohio.

Spirifer oweni Hall.

Some of the Dundee specimens of Spirifer approach *S. oweni* so closely that they may be regarded as representing that species. These are the accelerated derivatives of *S. manni*. They have been found in the upper beds. Elsewhere the species occurs in the Hamilton (Sellersburg), of the Falls of the Ohio and the Lower Traverse of Michigan. Other species of Spirifer recorded from the Columbus of Ohio are: *S. acuminatus* Conrad, *S. duodenarius* Hall, *S. eurytcines* Owen, *S. fimbriatus* Conrad, *S. macra* Hall, *S. machrothyris* Hall, *S. segmentus* Hall, *S. raricosa* Hall, and *S. raricostus* Conrad.

OTHER GENERA.

The genus MERISTELLA Hall is represented in the Columbus limestone by two species, *M. nasuta* Conrad and *M. scitula* Hall. An unidentified fragment of a species of this genus occurs in the Dundee of Michigan. The genus NUCLEOSPIRA Hall is represented by *N. concinna* Hall in the Columbus limestone, and the genus EUNELLA by *E. sullivanti* (Hall). Finally, the genus REEMERELLA is represented by *R. grandis* Vanuxem, a characteristic Hamilton form, found in New York, Indiana and Kentucky; and the genus CRANIA by *C. crenistriata* Hall and *C. (Crenicella) hamiltoniae* Hall, both Hamilton species, though the former also occurs in the Onondaga of New York, and the latter in the Jeffersonville of the Falls of Ohio.

The following table shows the range of the species in the Dundee and Columbus limestones:

TABLE LXVI.—SUMMARY OF THE BRACHIOPOD FAUNA.

	Dundee.	Columbus.	Typical Onondaga.	Typical Marcellus and Hamilton.
1. *Strophcodonta inaequiradiata*	×	×	×	....
2. *S. dundeensis*	×	×	×	....
3. *S. hemispherica*	×	×	×	....
4. *S. concava*	×	....	....	×
5. *S. costata (solidicosta)*	×	....	....	×
6. *S. finicosta*	×	....	?	×
7. *S. demissa*	×	?	....	×
8. *S. alpenensis*	×	×	×	×
9. *S. perplana*	×	×	×	×
10. *S. (Pholidostrophia) iowaensis*	....	×	×	....
11. *S. pattersoni*	....	×	×	....
12. *Strophonella ampla*	×	×	×	×
13. *Leptaena rhomboidalis*	×	....	....	×
14. *Schuchertella arctostriata*	....	×	×	....
15. *S. pandora*	....	×	×	....
16. *S. flabellum*	×	×	×	×
17. *Chonetes mucronatus*	×	×	....	×
18. *C. gibbosus*	×	×	....	....
19. *C. deflectus (C. vicinus)*	....	×	×	....
20. *C. acutiradiata*	....	×	×	....
21. *C. arcuata*	....	×	×	....
22. *C. yandellanus*	....	×	....	....
23. *Strophalosia truncata*	×	×	×	×
24. *Productella spinulicosta*	×	....	....	....
25. *Rhipidomella variabilis*	×	×	×	....
26. *R. vanuxemi*	×	×	....	×
27. *R. penelope*	×	....	×	....
28. *R. livia*	×	×	....	....
29. *Schizophoria iowaensis*	×	×	×	×
30. *S. propinqua*	?	×	×	....
31. *Pentamerella arata*	×	....	....	....
32. *P. cf pavilionensis*	....	×	....	×
33. *Camarotoechia dotis*	....	×	....	....
34. *C. billingsi*	....	×	×	....
35. *C. carolina*	....	×	×	....
36. *C. thetis*	....	×	×	×
37. *Tropidoleptus carinatus*	....	×	×	×
38. *Atrypa reticularis*	×	×	×	×
39. *A. spinosa*	×	....	×	×
40. *Cyrtina hamiltonensis*	×	×	×	×
41. *C. hamiltonensis var. recta*	×	....	....	×
42. *Spirifer bidorsalis*	×	×	×	....
43. *S. gregarius*	×	×	×	....
44. *S. grieri*	×	×	×	....
45. *S. manni*	×	×	×	....
46. *S. oweni*	....	×	×	×
47. *S. acuminatus*	....	×	....	×
48. *S. duodenarius*	....	×	×	×
49. *S. euryteines*	....	×	....	×
50. *S. (Reticularia) fimbriatus*	....	×	×	×
51. *S. macrus*	....	×	×	....
52. *S. macrothyris*	....	×	?	....
53. *S. segmentus*	....	×	×	×
54. *S. varicosus*	....	?	×	....
55. *S. raricostus*	....	×	×	....
56. *Meristella nasuta*	....	×	....	....
57. *M. scitula*	....	×	....	×
58. *Nucleospira concinna*	....	×	....	....
59. *Eunella sullivanti*	....	×	×	....
60. *Roemerella grandis*	....	×	....	×
61. *Crania craniatriata*	....	×	....	×
62. *Craniella hamiltoniae*	....	×	....	....

From the foregoing table it will be seen that the Hamilton species predominate. Of the 62 species recorded, 24, or 38 per cent., are unknown outside of the Onondaga elsewhere, while 28, or 45 per

cent., are either restricted to or most characteristic of the Hamilton group. Moreover, such very typical New York Hamilton or Marcellus fossils as *Stropheodonta demissa, S. iowaensis, Schuchertella arctostriata, Chonetes mucronatus, Strophalosia truncata, Productella spinulicosta, Rhipidomella vanuxemi, R. penelope, Camarotoechia dotis, Tropidoleptus carinatus, Cyrtina hamiltonensis, C. recta, Reticularia fimbriata, Nucleospira concinna, Roemerella grandis,* and *Craniella hamiltoniae* strongly suggest Hamilton affinities. Such is also the case with the species identical with those of the Traverse fauna of Michigan, as *Spirifer bidorsalis, S. euryteines, S. oweni, Stropheodonta alpenensis, S. plicata,* and *S. fissicosta.* The abundance of Onondaga types shows that the fauna is not true Hamilton, but rather a transitional fauna.

Class VII. PELECYPODA Goldfuss.

(LAMELLIBRANCHIATA de Blainville).

Genus SANGUINOLITES McCoy.

Sanguinolites sanduskyensis Meek.

This species, occurring in the Columbus limestone in Northern Ohio, appears to be represented in the Dundee by a large specimen, an internal mold about 55 mm. high. So far as can be ascertained from the fragmentary character, it can be referred to this species.

Genus PTERINEA Goldfuss.

Pterinea flabellum (Conrad)?

This species is doubtfully identified from the Columbus limestone, the specimens being large, coarse forms, very unlike the Hamilton types.

Genus ACTINODESMA Sandburger.

(GLYPTODESMA HALL).

Actinodesma erectum Conrad.

This large and coarse species is represented by several left valves in the Dundee of Michigan. It is characterized by an extended hinge line, slightly defined wing, ending in an acute point, and by coarse concentric growth striae and undulations. The species occurs in the coarser rock of the upper beds (Bed I) and 12 ft.

above the lower 20 ft. in the Sibley quarry. Elsewhere, it is a typical Hamilton form though occurring in the Jeffersonville of the Falls of Ohio. A closely related species, *A. subrectum* Whitfield, occurs in the Delaware limestone of Ohio.

Genus PLETHOMYTILUS Hall.

Plethomytilus ponderosus Hall.

This large species is represented in the Columbus of Ohio and the Onondaga of New York and Ontario. It has not been noted as yet in the Dundee.

Genus MYTILARCA Hall.

Mytilarca percarinata Whitfield.

This species is known only from the Columbus limestone of Dublin, Ohio.

Genus CONOCARDIUM Bronn.

Conocardium trigonale Hall.

This is a well represented species abounding in some of the layers of the Dundee in Southern Michigan. It occurs both as shells and internal molds. It is equally common in the Columbus of Ohio and occurs at the Falls of the Ohio. It is found in the Schoharie and Onondaga of New York. A closely related form occurs in the Traverse beds of Michigan.

Conocardium ohioense Meek.

This small species with sharply separated, produced posterior extremity, occurs in the Columbus limestone of Ohio, and the Jeffersonville (?) of the Falls of the Ohio. It has not yet been reported from Michigan.

Genus ACTINOPTERIA Hall.

Actinopteria decussata Hall.

This large and characteristic Hamilton species is represented by specimens on the average somewhat smaller than those found in the Hamilton beds. They have the characteristic form and obliquity, but generally lack the pronounced radii owing to the exfoliation of the shell. They are more or less scattered through the Dundee of the Sibley quarry, having been found in the 12 ft. bed above the lower 20 ft.; in Bed D (5 ft. bed); in Bed I (9 ft. bed); and in the beds above this. The species elsewhere is known only from the Hamilton beds.

A small specimen with strong concentric wrinkles decussating the striae, has been obtained from the 9 ft. bed. The striae are round and thicker than is general in the Hamilton specimens, but the form and obliquity are normal. The end of the wing projects slightly beyond the shell below.

Genus AVICULOPECTEN McCoy.

Aviculopecten similis (Whitfield).

This species, described by Whitfield from "the thin, shaly layers of bituminous limestone from above the 'bone bed' at Smith and Price's quarry near Columbus, Ohio," and referred to the Marcellus, is represented by a single left valve agreeing in all respects, including size, with the type. Its alternating striae and extreme convexity and small size are characteristic features.

Whitfield compares this with *Actinopteria decussata*, but the comparison is not apt. That species is more oblique and more elongate and the striae are interrupted. The hinge is unknown, but in form the species resembles an Aviculopecten. It is not improbable, however, that this is the young of *Aviculopecten sanduskyensis*.

Aviculopecten sanduskyensis Meek.

This species is described from the Columbus of Ohio, but has not been obtained from Michigan.

Aviculopecten crassicostatus Hall and Whitfield.

This occurs likewise in the Columbus limestone, but is still unrecorded from the Michigan Dundee. It was originally described from the Sellersburg of the Falls of the Ohio.

Aviculopecten sp.

A form with distant striae and strong concentric undulations has been obtained from the Sibley quarry above the 9 ft. bed. It is too poorly preserved for specific determination.

Genus MODIOMORPHA Hall.

Modiomorpha elliptica?

Recorded doubtfully from the Columbus limestone of Ohio.

Modiomorpha perovata (Meek and Worthen).

This species, described from Ohio, has so far not been found in Michigan, though there are indications that it may occur there.

Genus GONIOPHORA Phillips.

Goniophora perangulata Hall.

This acutely angular species, characteristic of the Schoharie beds of New York, has also been reported from the Columbus limestone of Ohio, but is still unknown in Michigan.

Genus PARACYCLAS Hall.

Paracyclas elliptica Hall.

This large species, with irregular and lamellose concentric striae, is abundantly represented in the Dundee of Southern Michigan and the Columbus of Ohio. The specimens are mostly compressed or distorted and are generally over an inch in diameter (1½ to 1¾ in. is more nearly the average). When perfect, they approach a circular form, while the depth or transverse diameter is one-half the vertical or over. Some specimens suggest in their striae an approach to *P. lirata* of the Hamilton Group. The species occurs in the Onondaga of New York, but is more abundant in the Mackinac limestone of Northern Michigan. It occurs more rarely in the Hamilton of New York. In the Falls of the Ohio region, it occurs in the Jeffersonville and Sellersburg.

The Dundee specimens are distributed more or less throughout the series exposed in the Sibley quarry. The species also occurs in the adjoining region of Ontario.

Paracyclas ohioensis Meek.

This small species, described from the Columbus limestone of Ohio, has also been obtained from the Sellersburg limestone of the Falls of the Ohio region. It has not been definitely identified from Michigan.

Summary of the Pelecypod Fauna. The pelecypod fauna of the Dundee and Columbus is more individualized than the brachiopod fauna, having proportionally more species peculiar to it. Nevertheless, there are a number of distinct Hamilton species present, such as *Actinodesma erectum* (Conrad), *Actinopteria decussata* Hall, and the small *Aviculopecten similis* Whitfield, described from the "Marcellus" of Ohio and *Paracyclas ohioense* from the Sellers-

burg of Indiana. Against these must be placed the number of distinctive Onondaga and Schoharie species, as *Plethomytilus ponderosus* Hall, *Conocardium trigonale, Goniophora perangulata* Phill., and *Paracyclas elliptica* Hall. On the whole, it seems as if the fauna inclines more to the Onondaga-Schoharie type than to the Hamilton type, since the most abundantly represented species belong to the former.

Class VIII. SCAPHOPODA Browne.

Genus DENTALIUM Linnæus.

Dentalium (*Laevidentalium*) *Martini* Whitfield.

This smooth, rapidly enlarging and moderately curved species is the earliest known from American rocks. It has been described from the Columbus limestone of Ohio, and not yet noted elsewhere.

Class IX GASTROPODA.

The gastropods as a whole are poorly preserved in the Dundee limestone of Michigan, occurring mostly as internal molds with the shell removed. As a result, identification of species is difficult, especially if, as is generally the case, compression has distorted the mold. The following determinations are subject to revision if better material is obtained.

Genus PLEUROTOMARIA.

Pleurotomaria (*Pleurorima*) *lucina* Hall.

This large species seems to be well represented by internal molds, which are commonly compressed, so that the spire appears lower than normal. The "band," when visible, seems to be near the middle of the whorl and vertical. Some of the compressed forms resemble *P.* (*Spiroraphe*) *arata,* but the superior-placed "band" of that species has not been observed. No surface markings are shown. The specimens are most abundant in Bed A (the 6 ft. bed) of the Sibley quarry, but occur also higher up (top beds and Bed G). They have also been collected from the Dundee of the salt shaft between 83 and 105 ft. from the top. *P. lucina* has been obtained also from the Columbus limestone of Ohio, and is characteristic of the Hamilton of New York; but it is reported likewise from the Onondaga of that state. It occurs in the Sellersburg

beds (?) and the Jeffersonville limestone of the Falls of the Ohio, etc.

Pleurotomaria (Euryzone?) hebe Hall.

This species, found in the Columbus of Ohio, is represented in the Dundee of Southern Michigan by two internal molds. These show only the form and apical angle of the species, the ornamentation being lost. The specimens are one from Bed A (6 ft. bed), and the other from the beds above the 9 ft. bed in the Sibley quarry. Elsewhere this species is found in the Onondaga of Western New York.

Pleurotomaria (Lophospira) adjutor Hall.

This ornamented species has been found in the Columbus limestone of Ohio and the Onondaga of New York, but has not been observed in the Dundee of Michigan.

Genus HORMOTOMA Salter.

Hormotoma (Hormotomina) maia (Hall).

This slender turreted species with rounded whorls is represented by fragments of internal molds in the Dundee of Southern Michigan (Bed I or 9 ft. bed). The characteristic duplicate character of the band is not well shown, though in one case the central carina is indicated. It was originally described from the Columbus limestone of Ohio, and has not been found elsewhere.

Hormotoma desiderata Hall.

This species, associated with the preceding in the Columbus limestone of Ohio, and distinguished from it by its greater apical angle, flatter shoulder of whorls, and simple band, has been doubtfully reported from the Onondaga of New York, but is still unknown from other localities. It probably occurs in the Dundee of Michigan; a mold approaching it has been obtained from the upper beds of the Sibley quarry. It has also been recorded from the Jeffersonville of Indiana.

Genus COELIDIUM Clarke and Ruedemann.

This genus seems to be represented by the internal mold of an unidentified species. The obliquity of the whorls is very slight, and there is a hollow axis from loose coiling. The whorls are round and the band is just below the periphery. It was obtained from the Dundee of the Sibley quarry; exact level not noted.

Genus EUOMPHALUS Sowerby.

Euomphalus (Pleuronotus) decewi Billings.

This species is most characteristically developed in the Columbus limestone of Ohio, but has also been obtained from the Onondaga of New York and Canada from the Jeffersonville of the Falls of the Ohio, etc., and from the Mackinac limestone of Northern Michigan. Its rapidly enlarging whorls, flat or sunken spire, and sharp keel readily distinguish it. In the collections of Dundee forms, it is represented by two young specimens showing depressed spire, a flat periphery, and rather rounded angles. Found in the upper beds.

Genus TROCHONEMA Salter.

Trochonema meekanum S. A. Miller (*T. tricarinatum* Meek).

This species, found in the Columbus limestone of Ohio, is represented by a single crushed specimen in the collections of Dundee material from Southern Michigan, recognizable from its carinated shoulder angle. From Bed I (9 ft. bed) of the Sibley quarry. It has also been found in the Jeffersonville limestone of Indiana.

Genus PLATYCERAS Conrad.

Platyceras dumosum Conrad.

A spiny species, represented by a number of individuals in the Dundee limestone, having considerable variation in form and spinosity. Spines generally represented by irregular nodes; the shell as a whole expanding rapidly. The apex is always strongly enrolled. Obtained from the lower beds, A (9 ft. bed) and D (5 ft. bed), and elsewhere in the Sibley quarry. It is found in the Columbus limestone of Ohio, in the Onondaga of New York and Ontario, and in the Sellersburg limestone of the Falls of the Ohio.

Platyceras attenuatum Meek.

This species, originally described from the Columbus limestone of Ohio, also occurs in the Dundee of Michigan. It is slender and narrow, with slight enlargements and rough nodes. It occurs some distance above the bottom of the beds (above the lower 20 ft.) in the Sibley quarry. The species has also been recorded from the Sellersburg bed of Charlestown, Ind.

Platyceras carinatum Hall.

This species, characterized by a sharp, carinated periphery, is represented in the Columbus limestone of Ohio, and by a small specimen in the Dundee of Southern Michigan. It occurs in the Hamilton of New York and the Sellersburg and Jeffersonville limestones of Indiana. Other species of Platyceras found in the Columbus limestone of Ohio, and probably also occurring in the Dundee of Michigan, are: *P. bucculentum* Hall, found besides in the Hamilton of New York and the Sellersburg and Jeffersonville limestones of Indiana; *P.* (*Igoceras*) *conicum* Hall, found also in the Hamilton of New York (also Onondaga?), and at the Falls of the Ohio (Jeffersonville and Sellersburg); *P. multispinosum* Meek also found in the Jeffersonville at the Falls of the Ohio; and *P.* (*Palaeocapulus?*) *squalodens* Whitfield.

Genus CALLONEMA Hall.

Callonema bellatulum Hall.

(*Isonema bellatulum* Hall).

This species, described from the Columbus limestone of Ohio, and occurring also in the Jeffersonville limestone of the Falls of the Ohio, is represented by a single internal mold from the Dundee of the upper five feet of the lower 20 ft. of the limestone of the Sibley quarry. The form of the whorls and the apical angle correspond exactly with those of the type specimen from Ohio, but no trace of the ornamentation is retained.

Besides the species already noted, the following have been recorded from the Columbus limestone of Northern Ohio.

TABLE LXVII.

		Range elsewhere.
1.	*Collonema lichas* Hall.	Onondaga of Western New York, Jeffersonville of Ind.
2.	*Callonema humile* Meek.	Sellersburg of Falls of the Ohio.
3.	*Palaeotrochus kearneyi* Hall.	
4.	*Turbinopsis shumardi* (Vern).	Jeffersonville of Falls of Ohio and New York?
5.	*Isonema depressum* M. and W.	Hamilton of Illinois.
6.	*Xenophora antiqua* Meek.	
7.	*Naticopsis acquistriatus* Meek.	
8.	*N. cretacea* H. and W.	
9.	*N. laevis* Meek.	Jeffersonville (?) of Falls of Ohio.
10.	*Loxonema leda* Hall.	
11.	*L. hamiltoniae* Hall.	Hamilton of New York, Sellersburg of Ind.
12.	*L. parvulum* Whitfield.	
13.	*L. pexatum* Hall.	Onondaga of New York.
14.	*Macrocheilus priscus* Whitfield.	
15.	*Cyclonema* (*?*) *doris* Hall.	Schoharie of New York.
16.	*Hormotoma* (*?*) *obsoleta* Meek.	
17.	*Bellerophon newberryi* Meek.	
18.	*B. propinquus* Meek.	
19.	*B. pelops* Hall.	Schoharie and Onondaga of New York, Jeffersonville of Indiana.

Summary of the Gastropod Fauna of the Dundee and Columbus Limestones.

While the majority of species are so far known only from these limestones, and are therefore of no immediate significance in correlation, a large number are elsewhere represented. Out of a total of about 15 species found in other localities, the division between the Hamilton and Onondaga is nearly equal. Most of the seven or eight Hamilton species are typical of that horizon, showing that the gastropod fauna must be considered intermediate. Probably many of the distinctive species will be found in the Traverse fauna of Northern Michigan, when the study of the latter is completed.

Class X. CONULARIDA Miller and Gurley.

(*Pteropoda* of authors).

Genus TENTACULITES Schlotheim.

Tentaculites scalariformis Hall.

This is a common species of certain layers of the Dundee of Southern Michigan. It has been found at various levels in the Sibley quarry, including Bed G (6 ft. bed), H (2 ft. bed), J (6 ft. bed) and above the lower 20 ft. It occurs most abundantly in the Dundee of the salt shaft, at about 105 ft. below the surface. It is likewise common in the Columbus limestone of Ohio, and has been recorded from the Onondaga of New York and from the Sellersburg and Jeffersonville of Indiana.

Genus CONULARIA Miller.

Conularia elegantula Meek.

This has been described from the Columbus of Ohio, but has not been noted as yet from the Dundee of Michigan.

Class XI. CEPHALOPODA Cuvier.

Genus ORTHOCERAS Breynius.

Several species of Orthoceratites occur in the Dundee of Southern Michigan, but no specimens sufficiently well preserved for specific identification have so far been found. From the Columbus of Ohio have been recorded *O. (Spiroceras) nuntium* Hall, known also from the Hamilton of New York; *O. ohioense* Hall, and *O. profundum* Hall, also known from Onondaga of Western New York.

Genus TREMATOCERAS Whitfield.

Trematoceras ohioense Whitfield.

This species, described from the Columbus limestone of Ohio, probably also occurs in the Dundee of Michigan, as indicated by several imperfect specimens.

Genus GYROCERAS Meyer.

Gyroceras (Ryticeras) cyclops Hall.

This species occurs in the Columbus limestone of Ohio, including the beds of Kelley's Island. It also occurs in the Onondaga of New York, but so far has not been recorded from Michigan.

Gyroceras (Ryticeras) columbiense Whitf.

This species, described from the Columbus of Ohio, has not been found elsewhere so far, but probably occurs in Michigan, since it is a common species.

Gyroceras (Centroceras) ohioense Meek.

This large species, described from the Columbus of Ohio, is also found in the Dundee of Michigan. In the specimens observed, the coiling is somewhat loosened toward the aperture, and the ornamentation of some individuals appears coarser than in the type. They occur in Bed I (9 ft. bed) and elsewhere.

Gyroceras (Gigantoceras) inelegans Meek.

This large species, originally described from the Columbus limestone of Ohio, also occurs in the Dundee of the Sibley quarry. A single large specimen has been obtained, with roundish smooth whorls enlarging rapidly. It has also been reported doubtfully from the Jeffersonville of the Falls of the Ohio.

Gyroceras seminodosus Whitf.

This appears to be a young form, possibly of *Discites inopinatus*. It has been found in the Columbus limestone of Ohio.

Genus NAUTILUS.

Nautilus (Discites) ammonis Hall.

A large nautilicone with deeply concave septa apparently belongs to this species. It was obtained from the Sibley quarry. It has not been recorded from Ohio, but has been found loose in Southern Michigan.

Nautilus (Discites) inopinatus Hall.

This nautilicone, characterized by sparse oblique nodes, on the ventrol-lateral angles, and smaller nodes on the umbilical margin, is represented by a single specimen from the Dundee of the Sibley quarry. It is quadrangular in section, but does not preserve the shell. The species has been found in the Columbus limestone of Sandusky, Ohio.

Genus POTERIOCERAS McCoy.

Poterioceras amphora (Whitf).

This species, described from the Columbus limestone of Ohio, also occurs in the Dundee of Michigan. Specimens were found in Bed B (7 ft. bed) of the Sibley quarry which correspond closely to the type specimen, having the aperture rather strongly contracted, the axis of the aperture being transverse to that of the rather strongly compressed shell. The species is unknown outside of these two formations, but closely similar, if not identical ones, occur in the Traverse group of Northern Michigan.

Poterioceras hyatti (Whitf).

This species was likewise described from the Columbus limestone of Ohio. It appears to be not uncommon in the Dundee of Southern Michigan. The curved form and aperture contracted below the top, where it again slightly expands, characterize the species. The axis of the aperture is parallel to the broad axis of the shell. This species has not yet been recorded from other horizons.

Poterioceras eximium (Hall).

This species has been recorded from the Columbus limestone of Ohio, but has not been found in Michigan. It was originally described from the Onondaga limestone of New York.

Poterioceras sciotense Whitf.

This species is at present known only from the Columbus limestone of Ohio.

Summary of the Cephalopod Fauna of the Dundee and Columbus limestone. The cephalopods more than any other class seem to be represented by peculiar species not yet found elsewhere. Of those known from other localities, however, only one (*Spiroceras nuntium*) is a typical Hamilton form, while three or four have previously been recorded from the Onondaga of New York or elsewhere. So far as the cephalopods seem to indicate, the fauna is less advanced than we should suppose from other classes of organisms.

Class XII. CRUSTACEA.

Order TRILOBITA.

Genus PROETUS Steininger.

Proetus conicus sp. nov.

This species is represented by a single cranidium. It is characterized by a conical glabella resembling that of *P. curvimarginatus* from the Schoharie of Pendleton, Ind., but has only three lateral furrows, the posterior one curving strongly backward to the occipital furrow, the middle curving slightly backward, while the upper scarcely curves at all. This species was figured and described by the author from the Hamilton shales of Eighteen-Mile Creek. It was provisionally and doubtfully referred to *P. curvimarginatus*. (Bull. Buffalo Soc. Nat. Sci., vol. VI., p. 316, fig. 261, 1898). *Proetus prouti* from the Hamilton of Iowa has a somewhat similar but less conical glabella. The specimen was obtained from Bed I (9 ft. bed).

Proctus crassimarginatus Hall.

This species, described from the Onondaga of New York and Ontario, is abundantly represented in the Dundee of Southern Michigan and the Columbus limestone of Ohio. It occurs mostly as pygidia, which are readily recognized by their strong convexity, the elevated, rounded axis, and strongly downcurving sides with rounded margins. The species ranges throughout the beds of the Sibley quarry and occurs in the other exposures of the Dundee and Columbus. It is known from the Jeffersonville and Sellersburg of Indiana and the Falls of the Ohio.

Proetus planimarginatus.

This species is readily distinguished from the preceding by its large flat pygidium with its gently convex axis, semi-elliptical outline, and pronounced margin. It occurs in the Columbus limestone of Ohio and is not uncommon in the Dundee of Southern Michigan.

Genus DALMANITES Emmrich.

Dalmanites (Chasmops) calypso Hall and Clarke.

This species is readily recognized by the angular, high and tuberculated axis of the pygidium with the pleurae grooved. The Michigan specimens resemble more nearly those figured by Kindle

from the Sellersburg beds of Ohio than those from the Onondaga of New York. (Compare Fig. 3, Pl. 30, Ind. Geol. Surv., 25th Ann. Rep't.; and Pal. N. Y. Vol. VII., Pl. XI. A, Fig. 19). In some specimens, the spines are less marked and the pleural grooves fainter. This is more like the type figured by Hall and Clarke. The species has also been recorded from the Columbus limestone of Sandusky, Ohio.

Dalmanites selenurus Green.

This species, known from the Onondaga limestone of New York, and the Jeffersonville of the Falls of Ohio, has been recorded from the Columbus of Ohio. It is thus far unknown in the Dundee of Michigan.

Dalmanites ohiocnsis Meek.

This species occurs in the Columbus limestone of Ohio.

Genus PHACOPS Emmrich.

Phacops rana Green.

This common Onondaga and Hamilton species occurs in the Columbus limestone of Ohio and is represented by pygidia in the Dundee of Southern Michigan.

Summary of Trilobite Fauna of the Dundee and Columbus Limestones.

So far as the Trilobites permit correlation, the Dundee-Columbus fauna must be considered an intermediate one between Onondaga and Hamilton, with a leaning toward the Hamilton side. Species of Hamilton affinity are: *Proëtus conicus* Grabau, *Chasmops calypso* Hall and Clarke var., and *Phacops rana* Green. Species of Onondaga affinities are: *Proëtus crassimarginatus* Hall and *Dalmanites selenurus* Green. The *Proëtus crassimarginatus* type seems to be a long lived one, for it is already represented in Southern Michigan in the Upper Monroe (Siluric). Against this may perhaps be offset, at least in part, the fact that both *Chasmops calypso* and *Phacops rana* occur elsewhere in the Onondaga as well as in the Hamilton.

VERTEBRATA.

Class I. PISCES.

Remains of Fishes are not uncommon in the Columbus limestone of Ohio and the Dundee of Michigan. A number of species have been described from the Columbus limestone. In the Dundee, so

far, have been recognized fragments of Onychodus. Machaeracanthus, and Rhynchodus.

GENERAL SUMMARY OF THE DUNDEE-COLUMBUS FAUNA OF SOUTHERN MICHIGAN AND NORTHERN OHIO.

The Protozoa and Stromatoporoids furnish at present little evidence for the age of the limestones, since the only recorded Protozoon (*Calcisphæra robusta* Williamson) is a long lived form continuing into the Carbonic, while the Stromatoporoids are not yet fully identified. The same is true of the Bryozoa, Scaphopoda, Conularida, and fish remains. The other classes, however, furnish more or less conclusive evidence regarding the age of this fauna as a whole. The corals and gastropods indicate an intermediate position for the fauna; the Brachiopods and Trilobites show a leaning to the Hamilton fauna; while the Pelecypoda and Cephalopoda incline to the Onondaga. In the Monroe formation, the Cephalopoda were found to be mostly of Lower Silurian (Niagaran) types, while the gastropods, corals, brachiopods, and trilobites were advanced forms. It is, therefore, safe to consider this fauna as strictly intermediate between the typical (New York) Onondaga and the typical (New York) Hamilton.

THE STRATIGRAPHIC POSITION OF THE DUNDEE-COLUMBUS.

Whitfield has shown that on the Sciota River and near Dublin, Ohio, the Delaware (Hamilton) and Columbus are separated by a thin bed of black shale with a fauna like that of the Marcellus shale of New York. The species found in this shale were: 1. *Lingula manni* Hall; 2. *L. ligea?* Hall; 3. *Orbiculoidea minuta* Hall; 4. *O. lodiensis* Hall; 5. *Chonetes scitula* Hall; 6. *C. reversa* Whitfield; 7. *Spirifer maia* (Billings); 8. *Leiorhynchus limitaris* Vanuxem; 9. *Aviculopecten? equilatera* (Hall); 10. *Pterinea* (*Aviculopecten*) *similis* Whitfield. Of these, Nos. 3, 4, 8 and 9 are typical Marcellus fossils of New York; Nos. 1, 2 and 5 are Hamilton species; No. 7 is an Onondaga form, and the others are new.

Whitfield's conclusion that these shales represent the Western extension of the Marcellus of New York is undoubtedly correct, as is clear from the fauna, as well as from the bituminous character of the sediments. These deposits seem to disappear northward, though the relationship of the Dundee and the overlying Traverse of Southern Michigan is not yet understood. Clarke* has recently shown that the base of the Marcellus of Eastern New York is

*N. Y. State Mus. Bull. 49, p. 115.

stratigraphically lower than that of the same formation in Western New York. At least 50 feet of black "Marcellus" shale overlying the Onondaga in the Schoharie region is represented in Western New York by Upper Onondaga. This is shown by the fact that the Agoniatite limestone, which in the Schoharie region is separated from the Onondaga by the above mentioned 50 feet of black shale, is an integral part of the Upper Onondaga limestone in Western New York. Clarke has interpreted these facts as representing the momentary eastward migration of the Upper Onondaga fauna of Western New York, where limestones continued to form after black shale sedimentation had commenced in the Helderberg region of Eastern New York. In comparing the New York sections with those of the Appalachian region, it appears that this equivalency is much more extensive. Thus at Cumberland, Maryland, the Romney shale, succeeding the Oriskany, probably with a hiatus, represents not only Hamilton and Marcellus of New York, but probably also the greater part, if not the whole of the Onondaga. The Agoniatite limestone has been found by Prosser in this section 170 feet above the base of the black shale. From analogy with the New York sections, we may argue that black shale sedimentation was going on here, while limestones were forming in New York, and that the shales, gradually spread northward and westward over the limestones. Just before they reached Western New York, a reversal of conditions seems to have occurred, the limestone conditions spreading eastward and southward, permitting the Agoniatite fauna to spread over territory which was previously the field of black shale sedimentation.

From the foregoing considerations it would appear that the thin bed of Marcellus shale of Central and Northern Ohio, represents the westward limit of spreading Marcellus conditions. These black muds overlie the Onondaga of Western New York to the extent of 55 feet, followed by the thin Stafford limestone (8 ft.) and about 45 ft. of Cardiff or Upper Marcellus shale. It seems highly probable that these Marcellus shales are represented westward by the limestones of the open sea and pure water, just as the muds of Eastern New York and of Maryland are represented westward by the limestones of the Onondaga. This would make the Columbus-Dundee the stratigraphic equivalent of the Marcellus shales of New York, and would place them stratigraphically above the Onondaga limestone, and since these limestones are thinner than the Onondaga of Western New York, it seems not unreasonable to assume that limestone sedimentation in the Ohio-Michigan region began long after it had set in, in the Western New York

region. This assumption would compel us to regard this region as one of non-deposition during all or most of Onondaga time. It may be that this region was the sea bottom under an ancient ocean current, with water sufficiently shallow to prevent sedimentation under it by its scouring action. Or else what is more likely, this may have been a land area during Onondaga time. In any case, the general absence of reef building corals from these limestones is significant, and argues for a later date for these sediments.*

The study of the Mackinac region has developed the fact that at the beginning of Onondaga time that region was in the state of a semi-desert, surrounded by limestone cliffs which furnished debris to be spread over the valley floor.† This limestone debris was derived from the Monroe formation and is incorporated with the succeeding Mackinac limestone, which, as a result, is brecciated to a high degree. The brecciated phase may be seen on the Island of Mackinaw and on the mainland to the west (Pt. St. Ignace). To a slight extent, it is still visible east of Mackinac City, where, however, the Mackinac limestone is largely made up of the finer sand and mud resulting from the breaking up of the limestone of the cliffs which surrounded the desert area.

The age of the limestone about Mackinac is probably greater than that of the Dundee of Northern Michigan. For this reason, and because the faunas are to a certain extent distinct, it is well to use a distinctive name for this formation. The name Mackinac limestone would seem to apply, and is so used in this report. This limestone appears to be more nearly equivalent to the Onondaga of New York, and it is at its base that the Schoharie fauna of Northern Michigan has been discovered.‡

On the view that the Mackinac limestone (the so-called Dundee of the Mackinac region) is the approximate equivalent of the Onondaga and Schoharie of New York, the succeeding Bell shales of Northern Michigan represent in part the horizon of the Marcellus, but with a different type of sedimentation. It is to this shale series that the Dundee-Columbus of Southern Michigan and Ohio corresponds, at least in part. Whether it began earlier, during the later stages of sedimentation of the Mackinac limestone, or whether the base of the Dundee and that of the Bell shale are approximately synchronous, will probably appear from

*See the discussion of Devonic Coral Reefs in the author's Principles of Stratigraphy—A. E. Seiler & Co., 1913.

†Grabau, A. W. Subaerial erosion cliffs and talus in the Lower Devonic of Michigan. Science, N. S., vol. 25, pp. 295-296. See also Principles of Stratigraphy, chapter XIII.

‡Grabau, A. W. Discovery of the Schoharie fauna in Michigan. G. S. A. Bull., vol. 17, pp. 718, 719: 1907.

further study of the northern faunas. In the latter case, the Dundee is probably also represented in part by the Lower Traverse limestones; and, in any case, it appears as if the Dundee is probably to be regarded as a member of the Traverse Group as developed in Northern Michigan.

Summary of Results. Summarizing the results so far obtained by the study of the fauna of the Dundee limestones of Southern Michigan, we find that both palaeontology and stratigraphy point to an intimate relationship between it and the Traverse (Hamilton), and that it is probably the stratigraphic equivalent of the Lower Traverse. This relationship and that with the Marcellus and Onondaga of New York is brought out by the following diagram.

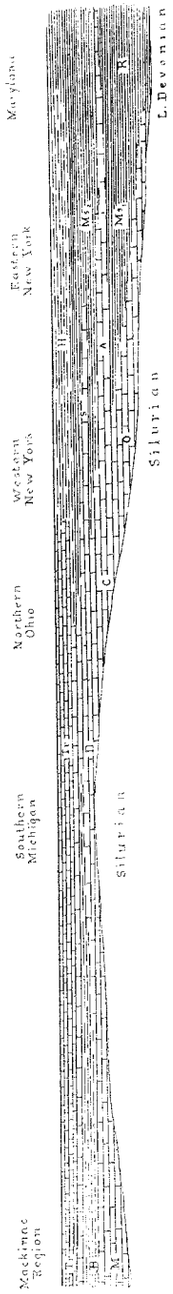

Figure 22. Ideal section from Maryland to Northern Michigan, crossing western New York, Ohio, and Northern Michigan.

A. Agoniatite limestone.
B. Bell shale (Lower Traverse).
C. Columbus limestone of Ohio.
D. Dundee limestone of Southern Michigan.
H. Hamilton of New York.
M. Mackinac limestone of Northern Michigan.
MS1. Lower Marcellus of Eastern New York.
MS2. Upper Marcellus of Eastern New York.
O. Onondaga of New York.
R. Romney shale of Maryland.
Tr. Traverse of Michigan—Delaware of Ohio.

SUPPLEMENTARY NOTE.

After the preceding report had been submitted, the admirable bulletin on The Middle Devonian of Ohio, by Clinton R. Stauffer has appeared.* It comprised a historical sketch of the study of the Middle Devonian of Ohio, with a brief review of the corresponding horizons of adjoining districts, followed by a detailed study of the various sections in Ohio with list of the species obtained from the various beds. A chapter, discussing the relationships of the Middle Devonian of Ohio with palaeogeographic maps, and one giving descriptions and illustrations of new or important species completes the work.

This discussion is of the greatest interest and significance in connection with the study of the Dundee, as well as the Traverse fauna, for this is the latest and most detailed information regarding the characters and faunas of the Ohio extension of our Michigan formations, and we are fortunate to have such a timely contribution. Extensive use will be made of it in the discussion of the Traverse faunas as a whole, but, for the present, reference will be made only to the section and faunas of the Columbus limestone of Northern Ohio and their bearing on the problem of the Dundee of southern Michigan.

In northwestern Ohio, where the rocks represent the direct continuation of the Michigan beds, the Columbus limestone is a fossiliferous gray limestone in the upper part, passing downward into a sparingly fossiliferous brown limestone, resembling the lower part of the same formation in central Ohio. The total thickness probably does not exceed 60 feet. The series rest disconformably upon the Lucas dolomite of the Monroe, and is overlain by the limestones and shales of the Traverse formation, there being no marked lithic change from the Columbus to the Traverse, the dividing line being indicated by the introduction of a large number of Hamilton species. There is thus no evidence of Marcellus sedimentation in this section which was beyond the reach of the mud-bearing currents from the east. The Black Shale overlies the Traverse disconformably as everywhere in this region.

In the vicinity of Silica, Ohio, just north of the Michigan line and 2¼ miles southwest of Sylvania, a number of quarries furnish good sections of the Dundee as well as the Upper Monroe beneath it. These were all visited by the writer in company with Prof. Sherzer, and the similarity of this rock to that of Monroe county, Michigan, was noted. The fossiliferous crystalline gray limestone

*Geological Survey of Ohio, 4th Series, Bull. 10, dated Nov., 1909, issued June, 1910.

of this section is 13 feet or more in thickness and underlain by 42 feet of compact brown limestone in marine beds, with a few fossils in the upper part. The rock is especially characterized by the large discs of the stem of an undescribed species of Hexacrinus and from it Stauffer records the following species:

FORAMINIFERA.

1. *Calcisphaera robusta* Williamson.

HYDROCORALLINES.

2. *Stromatopora ponderosa* Nicholson.
3. *Syringostroma densa* Nicholson.

ANTHOZOA.

4. *# *Acervularia davidsoni* E. & H.
5. # *Cyathophyllum rugosum* E. & H. (*Acervularia rugosa*) E. & H.
6. *Cladopora frondosa* Nicholson.
7. # *Favosites emmonsi* Rominger.
8. * *F. hemisphericus* (Troost).
9. *F. polymorphus* Goldfuss.
10. *# *Zaphrentis cornicula* E. & H.
11. *Z. gigantea* (?) Rafinesque.
12. * *Zaphrentis* sp.

BRYOZOA.

13. *# *Cystodictya gilberti* (Meek).
14. *Monotrypa tenuis* (Hall).

BRACHIPODA.

15. *Amphigenia elongata* (Vanuxem).
16. *Anthyris vittata indianensis* Stauffer.
17. *# *Antrypa reticularis* (Linn).
18. *# *A. speciosa* Hall.
19. *Camarctocchia billingsi* Hall.
20. *Chonetes arcuatus* Hall.
21. *Chonetes hemisphericus* Hall.
22. *# *Chonetes mucronatus* Hall.
23. * *Chonetes* sp.
24. * *Cryptonella lens* Hall.

25. *# *Cyrtina hamiltonensis* Hall.
26. * *Cyrtina umbonata alpenensis* Hall.
27. * *Eunella lineklaeni* Hall.
28. * *Nucleospira concinna* Hall.
29. # *Orthothetes (Schuchertella) pandora* (Billings).
30. # *Pentamerella arata* (Conrad).
31. *Pholidops patina* Hall and Clarke.
32. *# *Pholidostrophia iowaensis* (Owen).
33. *# *Productella spinulicosta* Hall.
34. * *Rhipidomella cyclas* Hall.
35. *# *R. vanuxemi* Hall.
36. # *Schizophoria propinqua* Hall.
37. *Spirifer acuminatus* (Conrad).
38. # *Sp. gregarius* Clapp.
39. # *S. grieri* (?) Hall.
40. # *Spirifer manni* Hall.
41. *S. segmentum* Hall.
42. *S. varicosus* Hall.
43. * *Spirifer* sp.
44. *# *Strophcodonta demissa* (Conrad).
45. *# *S. hemisphaerica* Hall.
46. # *S. inaequiradiata* Hall.
47. *# *S. perplana* (Conrad).
48. *Strophonella ampla* Hall.

PELECYPODA.

49. * *Actinopteria boydi* (Conrad).
50. * *Aviculopecten* sp.
51. *# *Conocardium cuneus* (Conrad). (*C. trigonale* Hall).
52. *Glyptodesma occidentale* Hall.
53. *Limopteria pauperata* Hall.
54. *Paracyclas elliptica* Hall.
55. *Modiomorpha concentrica* (Conrad).
56. *Penenka alternata* Hall.
57. * *Pterinea flabellum* (Conrad).
58. *Schizodus* sp.

GASTROPODA.

59. *Callonema lichas* (Hall).
60. # *Euomphalus decewi* Billings.
61. *Isonema (Collonema) humile* Meek.
62. *Loxonema robustum* (?) Hall.

63. # *Murchisonia (Hormotoma) desiderata* Hall.
64. # *Platyceras carinatum* Hall.
65. # *Platyceras dumosum* Conrad.
66. * *Platyceras* sp.
67. *Pleurotomaria arata* Hall.
68. # *Pleurotomaria lucina* Hall.
69. # *Trochonema meekanum* Miller.

CONULARIDA.

70. *Coleolus crenatocinctus* Hall.
71. # *Tentaculites scalariformis* Hall.

CEPHALOPODA.

72. *Gyroceras* sp.
73. *Orthoceras ohioense* Hall.
74. *Orthoceras* sp.

TRILOBITA.

75. *Phacops cristata* Hall.
76. # *Proetus planimarginatus* Meek.
77. *Proetus rowii* (Green).

BLASTIODEA.

78. *Nucleocrinus verneuili* (Troost).

CRINOIDEA.

79. * *Megistocrinus spinulosus* Lyon.

PISCES.

80. *Dipterus eastmani* Stauffer.

Of this series of 80 species, those marked with an asterisk (*) also occur in the Traverse group immediately overlying in northwestern Ohio. Thirty species (marked with #) or 37.5% have been obtained from the Dundee of southern Michigan, where a number of species, not yet recorded from northwestern Ohio, occur. Allowing for the personal element in identification, it probably remains true that 50% of the species identified from northwestern Ohio have not yet been found in Michigan, but will undoubtedly be found. At the same time, about 52 species out of 85 species

identified from Michigan, or 61%, have not been obtained from the Ohio section. Again allowing for the personal element, we may say that 50% of the Dundee species of northern Michigan have not yet been recorded from northwestern Ohio. The total number of species which we may consider identified from the Dundee of southern Michigan and northern Ohio is very near 125. Of these, the largest number of species is found among the brachiopods of which there are over 50 species or about 40% of the total number. Several of those found in the upper beds of the Sibley quarry, classed with the limestone as Dundee, were recorded by Stauffer only from beds referred to the Traverse in the Ohio extension. Among these is the form described in the preceding pages as a larger variety of *S. bidorsalis* Winchell, which Stauffer describes as a new species, *S. lucasensis* Stauffer. This form, in Lucas county, is found in the Traverse and it is not improbable that the upper layers of the Sibley quarry are their equivalent. Whether or not this is the case their ultimate relationship between the lower beds—the true Dundee, and the upper beds—typical Traverse, is undoubted, and there can be no doubt that continuous deposition of calcareous sediments was going on in the southern Michigan area while the black Marcellus muds of eastern New York and Pennsylvania were accumulating. The only question to be determined is, Did the lower or Dundee beds accumulate in the Michigan-Ohio area during the deposition of the post-Onondaga black muds of New York, or was this period synchronous with the pre-Dundee beds of southern Michigan, i.e. during the time when the beds referred to the Traverse in southern Michigan were accumulating? It seems almost certain that the former was the case as indicated by the more advanced character of the Dundee fauna and its comparative dissimilarity to the Onondaga.

In central Ohio, occurs the true Columbus fauna which is much richer in corals than is the Dundee. It seems as if we have here a somewhat earlier fauna than that of the Dundee, a fact further indicated by the Marcellus character of the upper Columbus beds of this region as already noted. The lists given by Stauffer greatly amplify that published by Whitfield, which was used as the basis of discussion in the preceding part of this report. In addition to the species listed by Whitfield the following have been obtained by Stauffer:

HYDROZOA.

1. *Dictyonema leroyensis* Gurley.

ANTHOZOA.

2. *Aulacophyllum convergens* Hall.
3. *Blothrophyllum cinctutum* Davis.
4. *Chonophyllum magnificum* (?) Billings.
5. *Cladopora frondosa* Nicholson. (Traverse in northern).
6. *C. pulchra* Rominger.
7. *C. robusta* Rominger.
8. *C. tela* (?) Davis.
9. *Cyathophyllum multigematume* (?) Davis.
10. *C. validum* Hall.
11. *C. sulcatum* (?) Billings.
12. # *Craspedophyllum archiaci* Billings.
13. *Diphyphyllum bellis* (?) Davis.
14. *Eridophyllum stramineum* Billings.
15. *Favosites goldfussi* d'Obigny.
16. *F. maximus* (Troost).
17. *F. radiciformis* Rominger.
18. *Heliophyllum porcilatum* Hall.
19. *Pleurodictyum problematicum* Goldfuss.
20. *Syringopora pereleyans* Billings.
21. *Zaphrentis spissa* (?) Hall.
22. *Z. ungula* (?) Rominger.

BRYOZOA.

23. *Coscinium striatum* Hall & Simpson.
24. *Fenestella erectipora* (?) Hall.
25. *F. parallela* (?) Hall.
26. *Fistulipora substellata* (?) Hall.
27. *Monotrypa tenuis* (Hall).
28. *Nemataxis fibrosus* Hall.
29. *Polypora celsipora* (Hall).
30. *P. celsipora minina* (?) Hall.
31. *P. flabelliformis* (?) (Hall).
32. *P. robusta* (Hall).
33. *Prismopora triquetra* Hall.
34. *Semicoscinium bi-imbricatum* (Hall).
35. *S. semi-rotundum* (?) (Hall).
36. # *Unitrypa lata* (Hall).
37. *U. tegulata* (Hall).

BRACHIOPODA.

38. *Amphigenia elongata* (Vanuxem).
39. # *Athyris vittata indianaensis* Stauffer.
40. # *Camarospira eucharis* Hall.
41. *Centronella glansfagea* Hall.
42. *Charionella scitula* Hall.
43. *Chonetes hemisphericus* Hall.
44. *Cryptonella lens* Hall.
45. *Cyrtina crassa* Hall.
46. # *Eunella lincklaeni* Hall.
47. *Meristella rostrata* (?) Hall.
48. *Metaplasia disparilis* (Hall).
49. *Pholidops patina* Hall & Clarke.
50. *Rhipidomella cleobis* Hall.
51. *Rhynchonella (?) raricosta* Whitfield.
52. *Spirifer divaricatus* Hall.
53. *Spirifer fornacula* Hall.
54. *Strophalosia cf. truncata* (Hall).
55. # *Stropheodonta concava* Hall.
56. # *S. inaequistriata* (Conrad).
57. # *S. parva* (?) Hall.

PALECYPODA.

58. # *Actinopteria boydi* (Conrad).
59. # *Aviculopecten cleon* Hall.
60. *Aviculopecten cf. pecteniformis* (Conrad).
61. # *Aviculopecten princeps* (Conrad).
62. *Clinopistha antiqua* Meek.
63. *Conocardium cuneus attenuatum* (Conrad).
64. *C. cuneus subtrigonale* d'Obigny.
65. *Glossites teretis* (?) Hall.
66. *Glyptodesma occidentale* Hall.
67. *Goniophora cf. hamiltonensis* Hall.
68. *Grammysia arcuata* (Conrad).
69. *Grammysia secunda* (?) Hall.
70. *Grammysia subarcuata* (?) Hall.
71. *Limopteria pauperata* Hall.
72. *Modiomorpha concentrica* (Conrad).
73. *Nucula niotica* Hall & Whitfield.
74. *Panenka alternata* Hall.
75. # *Schizodus appressus* (Conrad).

76. *S. contractus* Hall.
77. *S. tumidus* Hall.
78. *Solemya vetuta* Meek.

GASTROPODA.

79. *Bellerophon acutilira* (?) Hall.
80. *Bellerophon hyalina* Hall.
81. *Bellerophon rotalinea* (?) Hall.
82. *Callonema bellatulum* (Hall).
83. *C. clarki* Nettelroth.
84. *C. imitator* Hall & Whitfield.
85. *C. lichas* (Hall).
86. *Coelidium strebloceras* (?) Clarke.
87. *Cyclonema crenulatum* Meek.
88. *Loxonema gracillium* Whiteaves.
89. *Loxonema pexatum obsoletum* Hall.
90. *L. robustum* Hall.
91. *L. sicula* (?) Hall.
92. *Macrocheilus hebe* (?) (Hall).
93. *M. macrostoma* (Hall).
94. *Hormotoma eversolensis* (Stauffer).
95. *H. intermedia* (Stauffer).
96. *H. leda* Hall.
97. *H. quadricarinata* (Stauffer).
98. *Naticopsis comperta* Hall.
99. *Platyceras blatchleyi* Kindle.
100. *P. cymbium* Hall.
101. *P. erectum* (Hall).
102. *P. rarispinosum* Hall.
103. *P. rictum* Hall.
104. *P. thetis* Hall.
105. *P. lineatum* Conrad.
106. *P. subglobosa* Stauffer.
107. *Pleurotomaria cancellata* Stauffer.
108. *Pleurotomaria dublinensis* Stauffer.
109. *P. hyphantes* Meek.
110. *P. insolita* Hall.
111. *P. plena* Hall.
112. *P. procteri* Nettelroth.
113. # *P. regulata* (?) Hall.
114. *P. sciotoensis* Stauffer.
115. *Porcillia sciota* Hall & Whitfield.

116. *Pseudophorus antiquus* Meek.
117. *Straparollus corrugatus* Stauffer.
118. *Strophostylus varians* Hall.

CONULARIDA.

119. *Coleolus crenatocinctus* Hall.

CEPHALOPODA.

120. *Agoniatites discoideus* (Hall).
121. *Anarcestes cf. lateceptatus* Beyrich.
122. *Cyrtoceras cretaceum* Whitfield.
123. *Cyrtoceras metula* (?) Hall.
124. *Cyrtoceratites ohioensis* Meek.
125. *Gomphoceras arcuatum* Hall.
126. *G. gomphus* Hall.
127. *G. impar* Hall.
128. *G. mitra* Hall.
129. *G. plenum* Beecher.
130. *Gyroceras cyclops* Hall.
131. *Orthoceras dagon* Hall.
132. *Orthoceras molestum* Hall.
133. *O. sirpus* Hall.
134. *O. thoas* Hall.
135. *O. winchelli* Meek & Worthen.
136. *Tornoceras ohioense* Whitfield.

TRILOBITA.

137. *Chasmops anchiops* Green.
138. *Coronura diurus* (Green).
139. *Odontocephalus aegeria* Hall.
140. *O. bifidus* Hall.
141. *Phacops cristata* Hall.
142. # *Proetus rowii* (Green).

BLASTOIDEA.

143. *Codaster pyramidatus* Shumard.
144. *Nucleocrinus verneuili* (Troost).

CRINOIDEA.

145. *Dolatocrinus caelatus* (?) Miller & Gurley.
146. # *D. glyptus* (Hall).

147. *D. greenei* (?) Miller & Gurley.
148. *D. lacus* Lyon.
149. # *D. livatus* (Hall).
150. *D. major* Wachsmuth & Springer.
151. *D. ornatus* Meek.
152. *Megistocrinus depressus* (Hall).
153. *M. rugosus* Lyon & Casseday.
154. *M. spinulosus* Lyon.

PISCES.

155. # *Acanthaspis armata* Newberry.
156. # *Acantholepis fragilis* Newb.
157. *Cladodus prototypus* Eastman.
158. *Cyrtacanthus dentatus* Newberry.
159. *Dinichthys precursor* Newberry.
160. # *Machaeracanthus major* Newberry.
161. # *M. peracutus* Newberry.
162. # *M. sulcatus* Newberry.
163. # *Macropetalichthys rapheidolabis* Norwood & Owen.
164. # *Onychodus sigmoides* Newberry.
165. # *Palaeomylus crassus* (Newberry).
166. # *P. frangens* (Newberry).
167. *Psammodus antiquus* Newberry.
168. # *Rhynchodus secans* Newberry.
169. *Thelodus* sp.

A study of this table will show that, in spite of the abundance of Onondaga species, many typical Hamilton forms occur. Those marked with a # also occur in the Hamilton (Delaware and Prout) of Ohio. One of the striking features of this fauna is the abundance of the corals and hydrocorallines which, as pointed out by Stauffer, make extensive reefs in central and southern Ohio. These reefs are probably of the same age as those of the Falls of the Ohio region, and both may be contemporaneous with the reefs of western New York. The higher beds of the Columbus and the Jeffersonville limestones as well, probably represent in part, at least, the Marcellus of western New York and this is most certainly true of the Dundee of northern Michigan and northwestern Ohio. Here the corals are absent or but slightly developed, and this seems to be due to the fact that the coral horizon here is overlapped by the higher beds of the series, which here come to rest directly upon the Silurian. It is these higher beds, the typi-

cal Dundee, which are regarded as the representative of the Marcellus of western New York.

It thus appears that the further knowledge gained by the detailed study of the Columbus fauna, as presented in Stauffer's admirable bulletin, bears out the conclusions reached by the study of the Dundee fauna of southern Michigan. Stauffer suggests that the difference of the two faunas is in part accounted for by the occurrence of a land barrier. On the interpretation above given, this barrier becomes unnecessary, for the Michigan-northern Ohio area was land during the growth of the coral reefs in southern Ohio, western New York and the Falls of the Ohio region, as well as the northern Michigan and Canadian regions, and only became submerged by the slow northward and southward transgressions of the sea during the succeeding period, and the overlapping of the later over the earlier strata. A few further facts given by Stauffer agree well with this interpretation. Thus *Spirifer gregarius* becomes an abundant fossil in the middle part of the Columbus limestone of central Ohio, but, in the northern Ohio and southern Michigan areas, its place is at the base of the formation. *Meristella nasuta* is another species holding a similar relationship. This does not in any way negative Stauffer's conclusion that the coral fauna of the Onondaga came from the north. That conclusion may be well founded, as shown by the distribution of the corals. But the absence of the coral elements in the southern Michigan and northern Ohio areas is to be regarded as due to non-deposition there, rather than distinctness of waters, and to subsequent overlap of the higher beds of this series.

The full discussion of this problem is reserved for the monograph on the Middle Devonian Faunas of Michigan now in preparation.

Columbia University,

New York City.
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