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ALFRED C. LANE, STATE GEOLOGIST

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

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CHAPTER VII. ECONOMIC GEOLOGY, OR RAW MATERIALS OF THE COUNTY.

§ 1. Introduction.

There are many things classed as raw materials which are not so. Pig iron is classed as raw material by the user of it, but it is the finished product of the furnace man. Wool is the raw material of woolen manufacturer, but the product of the farmer. The only real raw materials are those to which man has contributed nothing of value by his labor. They are the natural resources of the country, and their value cannot be separated from the value of the land which controls their production. We do not, however, intend in this chapter to be rigidly academic in our classification, but intend to supplement Chapter V by trespassing somewhat on the domain of the Commissioner of Mineral Statistics and giving some account of the principal industries that are or may be developed in the county, in their immediate geological bearings. As the great foundation industry is farming, it is fit that we should begin with some notes on the soils.

The map of the Surface Geology, which is given on Plate VIII, may also be taken, as is obvious from the explanation, as in some degree a map of the soils also.

§ 2. Soils.

It is impossible to make a soil map of a county which shall be really accurate and, even then it would be so only for a short time, without going into a detail expensive beyond reason. Moreover, any wise man will look at a farm for himself before buying it. In a previous chapter (Chapter III, § 6, and Pl. VIII), in describing the physiographic districts we have suggested the general distribution of soils. Some hints may be of practical advantage, nevertheless. If an early map of the county such as Farmer's be consulted, it will be, found that a large part of the latter was described as swamp, and beaver dams are sometimes noted along the streams (Land Office maps and early railroad surveys). As the land is cleared and drained, the swamp would disappear but the vegetable mold or muck e. g., southwest of Caseville and Badaxe would remain as the base of a fertile black soil if not removed. The great fires which swept the county have, however, largely burnt off this vegetable mold and all the native seeds with it, as noted in Chapter X, on the flora. Not only that, but even now it is quite common, as I have observed for example in Fairhaven and Winsor townships, in clearing up low land in dry summers to burn off all the old vegetable mold. Something of possible fertility is thereby always lost, and when as sometimes happens, especially in the western shore district, below the mold there is nothing but clean sand, the lasting fertility of the land is seriously injured by this carelessness. However, it sometimes happens that these swamps were once shallow ponds, like the cranberry bog back of Hat Point and on Charity Island, and the swamps south of Badaxe and north of Ruth. In that case under the muck are likely to come beds of shell marl which are extremely fertile. Such marly drained lake bottoms make the most fertile of land, and a number of ponds offer tempting opportunities for such drainage. Bear Lake near Port Austin has thus been drained quite recently, and the lake bottom is now said to yield two and a half tons of timothy per acre. Consequently on the map Plate VIII of the surface Geology I .might easily have indicated the swamps as more extensive if I included all that land which had had a peaty black soil covering at one time. I have tried rather to indicate the more characteristically swampy parts, where it still exists and has considerable depth. On the other hand the map will soon be inaccurate the other way as the peat is burnt off.

The main soil of the county is clay, clay loam, or gravelly clay, and there are usually enough limestone pebbles scattered through it to keep it well supplied with lime and prevent souring. What Davis says about the greater amount of lime in the, surf ace clay wells is significant. At the same time there is enough mica and feldspar to keep it well supplied with potash, so that its fertility will probably be quite lasting. In the area enclosed within the outcrop of the Michigan series where the water is sulphated, land plaster will not be necessary. The fertilizer most needed would seem to be phosphates like guano.

A word about the boulders and stones strewn over the surface in belts very often roughly parallel to the shores of the county. Outside the district of glacial deposits in the boulder benches proper these thickly scattered boulders are likely to prove superficial, and once picked up, the soil beneath may prove comparatively free from stone. In the hill district, however, the case is different, and some of the moraine hills are likely to yield their crop of "hardheads" quite steadily. Sand dunes are indicated on the map, Plate VIII, by broken contours, as well as by the yellow dots assigned to sand, and I regret that the registration is not always all that it should be.

The least fertile soil in the county is that of the dune sands of the western shore. Yet it must be remembered that just such a soil in New Jersey has proven excellent material to hold plants upright while they were fed by fertilizers, and more money has been made out of small farms and small fruit in that region than can easily be computed. The sand region of Huron county is much resorted to about blueberry time, and when Saginaw and Bay City have a million population these sand dunes may be full of truck farmers. But successful farming on such a soil means fertilizers in large and frequent doses,—intensive cultivation. In the meantime these sands are not devoid of value for other purposes. Where the sand is thin, and this is frequently the case especially in the regions indicated as sandy above the

Algonquin, 610 feet, level the soil with a light six inches of sand above and clay below is most excellent for farming, and more easily worked than the stiffer clays.

§ 3. Sand.

Frequently dune sand is too round for building purposes, but certain parts of the sands of the district we have just mentioned are tolerably sharp. This is probably because they have been derived with comparatively little handling from the sandstones of the Marshall, which have angular grains of sand. The only points from which I know of shipments are from Port Austin, shipped by E. M. Carrington, and from Port Crescent, shipped by Miss E. Haskell. Sands equally good probably occur at intervals from New River to Oak Point. This sand is largely shipped to the Lake Superior copper regions where it is used as a lining for the bottoms of furnaces employed in copper smelting and for repairs; it requires for this work a moderately clean and sharp sand of medium fineness. It should be nearly pure silica, but requires a trace of iron or some fluxing material sufficient to cement the sand in a mass under a very high heat, but in no case melt it, or soften it so that any part of it will slag. It requires a sharp sand on the same principle that sharp sand will make the strongest mortar.

"The lake smelters have used 500 to 700 tons of this sand for a term of years, but are not likely to use so much in the future as there is a Pennsylvania sand that is more economical for the surface bottoms. The Port Austin sand will continue to be used for repairs."*

The sand from Port Austin and Port Crescent is "of the same quality, so far as we can see. The sand we get is shore sand washed up by the waves during heavy storms. That portion of the sand from any considerable distance from the shore is of no value to us*

There has been an analysis of the sand made but we have not been able to get it, and it has not been deemed necessary to make another as we are assured by the users, that next to its being nearly pure silica, the essential is its angularity. We do not know why it must be close to the waves unless that the farther it gets from the waves the rounder it becomes by rebounding; possibly the lime that exists in the water of the lake and would be deposited on evaporation furnishes just that minute amount of flux necessary.

An examination of the sand shows that it is mainly of quartz grains though little garnets and bits of feldspar, etc., occur. There is much less iron than many sands have. The form of the grains is sharp and much more irregular than in many sands, for example the Sylvania sand and similar beds. It is in other words nearly the sharp grits of the Marshall disintegrated by solution of the sideritic cement and not essentially rounded in rehandling. Besides being shipped to Hancock and Dollar Bay in the copper country it is also shipped to Toledo and Detroit. The price realized was in 1896 $1.00 a ton loaded or 40 cents unloaded. In 1897, at least 600 tons were shipped to Lake Superior.

From what has been said it is obvious that this sand would make an excellent mortar or all round building sand.

*(Letters of J. R. Cooper, Supt. Detroit and L. S. Smelting Works.)

§ 4. Sandstones and grindstones.

The same angularity which we have just noticed in the sand is also to be noted as an important fact in the grains of the grindstones of the Marshall group. Like the Berea they may properly be called "grits." The principal use of the sandstone has been for whetstones and building, and the former use is so much the more important that we treat it first.

(a) The grindstone quarries.

The grindstone quarry industry was one of the earliest developed in the county. It was started by A. C. Peer in 1850. It has been mainly carried on by two firms. Mr. Peer's firm became Johnson Peer & Wallace, and later the Huron Grindstone Company with L. R. Wallace as superintendent. The other company is the Cleveland Stone Company with Geo. S. Robertson as Superintendent. In 1896 the Cleveland Stone Company had its main quarry on Sec. 24 and 25 and the Huron Grindstone Company on Sec. 23, T. 19 N., R. 13 E., but the coast all along to Sec. 30, where the quarry was in Winchell's time, has been worked over, the waste stone being thrown into the old workings, which have in some cases then been reoccupied by buildings. There is quite an area yet to be worked along shore, and apparently along Willow Creek the same or similar beds can be found. This stone has already been partly described in a previous chapter. The thickness of the most uniform bed is about 15 feet, and often the cross-bedding is entirely obscure, so that the rock seems perfectly homogeneous. This is the most valuable part. At other times the cross-bedding interferes with the production of large stones. Stones weighing up to 7,800 pounds, or say three tons, have been secured. I noticed one that had been abandoned for its original purpose and turned into a fine drinking trough, about 7 feet across. The face of the quarry is liable to check—crack—under the action of frost and therefore it is the custom to protect the face of the quarry with sawdust in winter. The best stone is turned into grindstones of various sizes, which are sold all over this country and even sent abroad, and are especially valuable for not glazing. This is due to the fact that the sharp angular cutting quartz grit is embedded in a softer cement of mica, siderite, clay, etc., which wears away just fast enough not to allow the rock to polish. It is the combination of evenness of grain, sharpness of grit, and cementing material just soft enough which gives this stone its peculiar value.

The smaller material is made into scythestones (Sp. 19017), and the waste material remaining is used for building and underpinning. For this purpose it is not so very well adapted, owing to its porosity, and tendency to check already mentioned. It is a much better grindstone than building stone. However, it has a pleasing color, blue to bluish grey, with a greenish cast, and has been more or less worked up into caps and sills, etc. A number of underpinnings and one or two houses may be noticed in Badaxe made of this stone. The Sebewaing Marble Works also use it for sills to marble gravestones. Its fine grain and free working make it very amenable to the mason's chisel.

Underneath the sandstone layers come more argillaceous ones variously called blue shale, soaprock, etc., which are quite firm and being presumably less porous would, I should think, be even better for sills and underpinning than the main quarry. The underpinning of the Dunster block in Badaxe is, I understand, of this bed.

The following figures for which we thank Mr. H. W. Caldwell give the product of the Cleveland Stone Co. for 1898 and 1899:

From Grindstone City.		From Port Austin.		Description.
1898.	1899.	1898	1899.	
1,626 cu. ft........	681 cu. ft.........	....	....	Block stone.
2,990 cu. ft........	2,288 cu. ft.......	....	....	Sawed flagging.
3,307 tons..........	3,733 tons.........	....	....	Perch stone.
3,606 tons..........	3,855 tons.........	1,232 tons.........	1,576 tons.........	Loose grindstone.
6,320 pcs..........	11,292 pcs.........	5,292 pcs..........	8,532 pcs..........	Mounted "
3,957½ gross.......	4,259 gross........	1,316 gross........	1,951 gross........	Scythe stones.

(b). The Babbitt sandstone quarry.

This quarry was opened in the Napoleon sandstone near Rush Lake, on Lot 3 of Sec. 15, T. 18 N., R. 11 E. Mr. B. Smalley of Caseville was also interested in this quarry. An example of sandstone may be seen in the monument to the memory of his wife, Nancy M. Smalley, in the cemetery near Caseville, which was erected in 1887. Buckley in his report on the Building and Ornamental stones of Wisconsin* says that coarse pores are not as deleterious as fine pores. So here in spite of the high porosity of the stone (Sp. 19161, Table II, p. 90) the monument seems to have held its lettering well. The sandstone is rather coarse (grains about 1 mm. or one twenty-fifth of an inch in diameter), nearly white with a buff or olive hue showing minute brown points, which might on deeper quarrying prove to be weathered pyrite. It is at present owned by Mrs. J. W. Babbitt, of Ypsilanti, and has not been operated lately. Some of this sandstone has been shipped to Detroit, and may be seen in a house there.

*Bull. Wis. Survey, No. IV, 1898, p. 21, etc.

§ 5. Shales and clays.

The use of an argillaceous bed next to the grindstone for underpinning in the Dunster block opposite the Irwin House in Badaxe I have just mentioned, but in general the shales and clays are not firmly enough consolidated to make building material without farther treatment. In other words they are suited better for brick. Most of the clay of Huron county that I have examined have occasional little pebbles of limestone that cause a certain amount of loss in making brick, as in the burning process such pebbles slake more or less, and the escaping gas "bursts the brick, and there is a spot of slaked lime left as a weak spot in the brick." Such waste brick, however, make excellent material for road mending, and should be widely used.

The clay at Sebewaing is washed, as is more fully described below and in Vol. VIII, Part I. The clays are probably, like almost all the surface clays of the state, calcareous, containing much carbonate of lime in a finely divided state. This tends to produce white brick as it neutralizes the iron but such clays are readily fusible and cannot be burned hard without melting.

The shales, especially some of the beds of the Michigan series, seem quite plastic and pure, but it is dangerous to judge from churn drill samples. They are exposed extensively only by the coal working around Sebewaing, in connection with the grindstones as already described, thence south to the Point aux Barques lighthouse, and on Section 32 White Rock. Here they are well exposed in the bluffs for over a quarter of a mile, and also in a bed of a creek up to the road. This last exposure appears to be a very clean shale, and well suited for making high grade clay products. It is similar in character to the shales used for the manufacture of Portland cement in Branch county and should the marl beds back of the Forest Beaches or in Sanilac county prove to be extensive, it might well assist in the establishment of a cement industry. A description of the shales near White Rock and their tests, and analysis will be found in Part I of Vol. VIII by Prof. Ries, as follows:

White Rock.

Excellent exposures of Coldwater shale occur along the shore of Lake Huron between White Rock and Forestville (Part III), but they have not thus far been utilized.

The shale forms a line of cliffs, and when fresh appears brittle and gritty; in places, however, it has mellowed down to a tough clay.

The rock is a thinly laminated shale (179), which contains much sand of a very fine nature, and slakes slowly along the layers. It worked up with 19% of water to a mass of fair plasticity. The bricklets had an air shrinkage of 4%, and the briquettes had a low tensile strength of 36 to 42 pounds per square inch.

Incipient fusion took place at 03, vitrification at 3, and viscosity at 6. The total shrinkage when the vitrified condition was reached was 11%, the color being deep red.

An analysis of this material yielded to A. N. Clark:

Silica	58.70
Alumina	18.31
Ferric oxide	7.19
Calcium carbonate	1.80
Magnesium carbonate	.98
Alkalies	3.67
Water and organic matter	9.35
	100.00
Ferrous oxide	2.73
Total fluxes	13.64

Among the brickyards are:

(a). Warren's brickyard, Badaxe, on the east branch of the Pinnebog River, on the south half of the southeast quarter of Sec. 13, Colfax, T. 16 N., R. 12 E. This brick has been used for the jail, school-house and private houses and banks in Badaxe, and the Wadsworth schoolhouse, and has been shipped as far as Port Austin, Harbor Beach, and Gagetown. The color varies from cream to red. The red are the outside of the kiln, the white inside, and the sandy clay under the main clay bed which is somewhat used also makes a whiter brick. Toward the top of the burning they become chalky, the top one or two layers of each burning being spoiled with the amount of mineral in the water. Of the refuse brick the better are used for scoving, i. e., outer casing of the next burning. The section of the clay used is:

One foot of clay loam, beneath which are 5-6 feet of clay, then sandy clay.

This clay is not directly connected with the present Pinnebog, but may probably date back to the time of the Forest Beach. About a quarter of a mile west of the road on the east line of Sec. 13, it is said to become very bouldery with Canadian hardheads,—one or two as much as six feet long,—an old boulder bench.

In this yard the limestone pebbles are not as much trouble as the mineral water, i. e., soluble salts, the remedy for which Dr. Ries gives in his report, Part I, of Vol. VIII.

The yard has been at work some 13 years. In 1895, 300,000 brick were burnt, and it is thought to have averaged about 250,000 brick a year.

(b). Elkton brickyard, Ginter and Heist, on the southeast quarter

of the southwest quarter of Sec. 3, T. 16 N., R. 11 E., near the west branch of the Pinnebog. Here the clay is directly from the valley of the Pinnebog, and is probably an alluvial clay, the section being 21/2 feet of dirt, under which lie 4 feet of clay.

At the south end is a bed which yields a light orange red brick (Sp. 19228), while the ordinary brick is of a cream color like Sp. 19223. Probably in the former bed some of the lime which neutralizes the coloring matter of the iron is leached out. They are more or less bothered with limestone pebbles, causing a loss in burning (Sp. 19224). The product in 1896 was 500,000 brick. The brick has been shipped as far as Unionville and Fairgrove, and may also be seen in J. Ryan's house in Badaxe.

(c). Sebewaing brickyard, Ernst Reinhold, on the southwest quarter of the southwest quarter of Sec. 9, T. 16 N., R. 9 E.

This yard is close to the valley of the Sebewaing and gives a red brick. They are removing the pebbles by washing. See report on clays and shales by H. Ries Vol. VIII, Part I, which also gives illustrations, as follows:

Sebewaing.

"The surface clay used at the Sebewaing brickyard is a river clay, and is overlain in places by dune sands. The upper two or three feet burns red, while the lower clay in the bank is very calcareous and burns buff. Both clays contain large quantities of lime pebbles, and they are especially numerous in a layer at the juncture of the two kinds of clay. In order to eliminate these from the red-burning clay it is treated to a washing process, which consists in putting the clay into a circular sheet iron tank, with water, and the mixture stirred by arms attached to a vertical shaft. The effect of this stirring process is to get the clay particles in suspension, while the sand and concretions fall to the bottom of the tank. In front of the machine is a screen with half inch meshes, through which the washed and suspended material is discharged into a trough about 50 feet in length. At the end of this trough is another screen with one quarter inch meshes. After passing along this trough most of the sand is dropped, and the clay and water flow out into the settling tanks which have wooden sides and a sand bottom. The water evaporates from these and leaves the washed clay forming a layer about six inches thick in the bottom of the trough. While the clay is settling and drying in the trough the material being discharged from the machine at a later period is conducted into a second or third trough.

"It is stated that two men can put enough clay for 16,000 bricks through the machine in one day. This ingenious washing process is a highly important one, and could be utilized at many other localities in the state where there are red burning clays containing lime pebbles or concretions. It furthermore removes the coarse sand from the clay and permits of the production of a much smoother brick, a point which is serious when front brick are to be manufactured.

"At the Sebewaing brick works the clays are molded in a Quaker-soft mud machine, dried on pallets and burned in scove kilns. While the product is chiefly common bricks still some pressed bricks are made in various shapes and sizes. Their surface is, however, unfortunately roughened by the use of very coarse molding sand."

The burnt product is shown by Sp. 19229 and the clay, which is coarser and sandier than some of the other clays, by Sp. 19230.

The following is the result of some absorption tests on bricks of this county which shows a high ratio.

Number of specimen	19168	19225	19226	19227
Locality.		Elkton yellow.	Elkton red.	Sebewaing red.
Absorption rates, i. e., ratio of weight wet to weight dry	1.25	1.29	1.17	1.17

(d). In the lower valley of the Pigeon, on the southwest part of Sec. 13, T. 17 N., R. 10 E., Caseville, New Haves, P. O., Chas. F. Leipprandt had a brick and tileyard which he afterward sold to Chas. (?) Steinman who moved it to the southeast quarter of the same section. This yard also yielded a red brick. There are numerous other places along the river valleys where clays equally well suited for brick making may be found. There are some not far from the town of Pigeon. These river clays are, however, quite variable in character. It is not likely that any of the surface clays will be free from limestone pebbles, and as adjacent counties are at least as well supplied with such material, that any brick made from them will find a very wide market. See p. 213 regarding paving brick.

§ 6. Road metal.

There is no feature more marked in the recent development of the United States than the attention paid to better roads. In view of the recent development of the bicycle industry, and the figures showing what a large proportion of the cost of shipping wheat to Liverpool comes in getting it to the railroad, the attention paid is amply justified. A few notes on the care of the roads may be of value. See also Part I of this volume. The essential thing in a good road is that it should be well drained, i. e., with a coarse and porous underpinning, and with a hard surface not likely to soften when wet. The cementing properties of limestone are valuable to produce the latter feature. There is ample material in the county for making excellent roads. The sandy roads of the shore should be mended with a clayey material. Clay is not bad; shale or argillaceous limestone is better. Around Sebewaing the burnt waste of the coal mines is used with excellent effect,—the best material of all. (Sp. 19236). In Missouri clay is burnt expressly for road material. Burnt brick waste will not be bad. An excellent road may be made from the limestone waste, though somewhat dusty.

In general, however, the roads tend to be too clayey. For such roads coarse gravel is a good material for road mending, and the old Forest Beach shore lines described in a previous chapter and more elevated gravels furnish excellent material which is largely drawn upon. The coarse material is better for road mending and is also good ballast for railroads. The presence of a considerable amount of lime and iron is of value as adding cementing power. Between 60 and 118 feet above present lake level are numerous other generally more sandy deposits. The Bayport limestone is largely crushed for macadam. Crushed boulders would also be excellent.

The possibilities of making paving brick have not yet been developed, but I may say that it is to the shales of the coal measures or Coldwater series of the eastern coast that I should look.

Dr. Ries makes the following report:

Sebewaing.

"The Michigan Standard Coal Co. has a shaft at the southern end of the town at which the coal is interbedded with shale.

"That over the coal is a brittle black bituminous shale with numerous nodules of pyrite, while that under the coal is gray and sandy. On exposure to the air it slakes readily to lumps the size of a hazel nut, but to get it finer requires grinding. Some of it was tried at the neighboring brickyard, and it was not found possible to melt it in the scove kilns.

"It was consequently thought desirable to test it physically.

"The sample collected (182) gave no effervescence with acid, and slaked very slowly in water. When mixed with 17% of water it gave a mass of good plasticity whose air shrinkage was 5%, and the air dried briquettes made from it had an average tensile strength of 100 pounds per square inch with a minimum of 90 lbs.

"In burning, incipient fusion began at cone 1, with a total shrinkage of 8%, the color being buff. It vitrified at 5, and became viscous at 9. The shrinkage at vitrification amounted to 13%. The soluble salts were .25%."

§ 7. Limestone.

The other material that needs particular notice is limestone. This has been used not only in macadam, but also as paving blocks.

(a). Bayport limestone quarries. See pp. 110 to 112.

The quarries now operated are upon Sec. 5, Winsor, T. 16 N., R. 10 E. As we have mentioned, similar beds lie near the surface to the southeast and to the northwest and have been, opened on North Island. The present location is exceptionally favorable as regards drainage. The section of the quarry is given in Figure 8, and the general extent of similar stone may be seen on Plate VII the part above the 620 foot contour in the neighborhood being especially to be noticed. A number of test pits near the Shebeon on the east half of the northwest quarter of Sec. 14, T. 16 N., R. 9 E., show similar limestone, but at a lower level where the water would be more in the way.

An elaborate illustrated description of these quarries appeared in Stone for August 1898, by A. C. Benedict.

The main products of the quarries are limestone which is burnt into lime, paving blocks, crushed stone for macadam, and building stone. The top layers appear to be least magnesian, and hence best for lime. The analysis published in Vol. V, is from layer No. 1, p. 110, as follows:

Silica	3.330
"Oxide lime and alumina" (should be iron instead of lime)	1.334
Carbonate of magnesia	.944
Carbonate of lime	91.538
Phosphorus and sulphur	traces
Organic matter and loss	2 854
	100.000

(Quicklime, 51.29.)

With so low a percentage of magnesia, the lime will be a hot strong lime which will take much sand. Prof. Langley of Pittsburg says: "This is a very pure limestone and unusually free from anything except carbonate of lime. It contains nothing injurious to iron, and in my opinion will give entire satisfaction in the blast furnace." It seems as though picking of the upper layers might give the exceptionally pure limestone required in the soda ash business. The lower layers are undoubtedly more magnesian, and probably contain more bituminous organic matter. The percentage of Si O_2 is noteworthy. This is or was undoubtedly largely in the form of soluble, organic Si O_2 and some of the layers are saturated with it. It adds much to the hardness of the limestone and its availability for macadam, etc.

We quote from A. C. Benedict as follows:

"The upper sixteen feet in the quarries consist of even-bedded, homogeneous, tough, drab-colored limestone, followed by twenty feet of sandstone suitable for grindstones. This is followed by from thirteen to fifteen feet of fine brown-stone, which is underlaid by fifty feet of shale. A space of seventy-five feet was quarried to the shale for experimental purposes, and a fine quality of sandstone found.

The quarry may be divided as follows:

Ledge No. 1. 4 feet thick; used for macadam.

Ledge No. 2. 3 feet thick; burned for lime," (No. 1 of Fig. 8).

Ledge No. 3. 3 feet thick; building stone," (Nos. 2 to 5 of Fig. 8).

Ledge No. 4. 3 feet thick; building stone.

No 1 is drab, or dove-colored, limestone, very hard and tough, used entirely for macadam, for which it is eminently fitted. The ratio of absorption, as determined by Prof. J. B. Johnson, C. E., Washington University, St. Louis, Mo., is one-half to seven-tenths of 1 per cent. Prof. Johnson's conclusions, after an exhaustive study of this quarry is as follows:

'This is the strongest limestone of which I have any record. It is as strong as the best granite. It is also impervious to water, that is, non-absorbent as granite, and will weather perfectly. It is also as heavy as any limestone on record and as heavy as most granites. It is. therefore, an ideal material for all building and structural purposes, as well as for roads and sidewalks. For dressed stone it is rather hard, but for rock faced masonry it is perfectly adapted. A macadam road constructed of this rock (Ledge No. 1) crushed, properly graded, and well rolled, would make the best possible road for the country, or for the smaller cities and towns; and for cement sidewalks, a concrete made up of this rock crushed fine and used with Portland Cement, would be as good as the best "granitoid" walk in which granite is used.'

"Two carloads of Belgian blocks were placed in Tilden street, Saginaw, Mich., at the east end of Johnson street bridge across the Saginaw river, about eight years ago. and Stone recently examined this work and can testify that neither the traffic they have carried nor the elements have had an appreciable effect on them, except to make the top a little smoother than when fresh from the quarry. A material with this record certainly merits the careful investigation of users of this class of stone."

For macadam we need a tough non-porous, hard rock. Tests (Table II, p. 90) agree with Johnson that the Bayport limestone is in many layers practically non-porous, the water of the formation finding its way either in dissolved crevices or in the sandy layers. An excellent test of the utility of the rock for paving and macadam may also be found from its behavior under the drill. If with a core drill or churn drill progress be slow, and especially if with a core drill there be a large percentage of core saved, which comes out in large pieces, the indications are good. For example out of the first 28.3 feet drilled in the quarry hole No. 1, the aggregate of core saved was 18.4 feet, a portion of this loss being of earthy deposits between layers. In the lower grindstone layers more than half the core was lost, as this comparatively soft rock was broken up. A high crushing strength is also a desirable thing. A test at the Watertown Arsenal by Capt. Butler gave a crushing strength of 26,110 lbs. The weight was given as 170 pounds per cubic foot and specific gravity 2.72. A detailed description of these tests is quoted by A. C. Benedict in the article referred to. The specimen was 2.61 inches thick, with a compression surface of 29.65 square inches. It is true, however, as of all limestones, that this limestone is softer than iron and hence every concussion with iron wheels scrapes off a minute portion of white calcareous powder, so that suck macadam tends to be dustier than that made from the more silicious rocks. Rain will dissolve this powder and soak it down to cement the macadam. In the opener country this dust will soon be dissipated, but in the city it may be unpleasant. Watering with the mother liquor of brines, or other solutions of salts that draw water would tend to check this tendency of this form of macadam. A number of the roads and the bicycle track near Bayport show what an improvement this macadam makes over clay roads. It has also been used in Saginaw.

This stone has been shipped quite a distance for building purposes.

We cite the following matter from Mr. Benedict's article. It must not be forgotten that his 3 and 4 are 2, 3, etc., of Fig. 8 and of Rominger's section.

"Nos. 3 and 4 are used for various building purposes. The following analysis, together with the tests relating to the crushing strength of the stone, show its value for macadam, paving blocks for streets, cross-walks, curbing, sidewalks, foundations, bridge piers, buildings, etc.:

Carbonate of lime	61.52
Carbonate of magnesia	14.50
Sand	20.85
Clay	2.04
Phosphate of lime	.09
Bisulphide of iron	.15
Water	.85
Total	100.00

"This analysis shows the stone to be a magnesian dolomite with an addition of a notable amount of sand which gives it an appreciable power to resist the action of the elements, and also the abrasive effects of travel where it is used for streets or sidewalks. The low per cent, of water, which is a measure of its absorptive power, renders it practically frost proof and gives it unusual value for all outdoor uses. It is very compact, tough, even-grained stone of drab, or dove-color, certain layers of which with age bleach to almost a pure white, resembling marble, but with this advantage over marble, that it is so close-textured that dust, soot, etc., do not adhere to it, but are washed off by rains leaving a clean, fresh-looking face at all times. Tested both artificial and naturally by freezing processes it resists admirably, showing its high rank as building stone."

The station at Flint and the offices of the Saginaw, Tuscola and Huron in Saginaw are examples of its use. I do not think that any limestone is a very satisfactory building stone in cities where soft coal is in use, as it soon becomes dingy, but the dove-colored shades of the Bayport limestone harmonize not unpleasantly with the dingier smoke-stained parts.

(b). Soule limestones.

As I have remarked, near Soule there are outcrops of argillaceous limestones of the Michigan series. A good part of Sec. 19 in Meade township is owned by the Michigan Cement Company, which beyond some test pitting has done nothing to develop the property. It is understood to be under the same control as the cement quarries near Milwaukee. As may be seen from Plates VII and VIII, the northeast quarter of Sec. 24, and Sec. 18, in T. 17 N., R. 11 E., and Sec. 19, T. 17 N., R. 12 E., seem also to be favorably situated for development. Elsewhere the limestone may be below water level, though it might be found northeast of Caseville adjacent to water. The limestone (Sp. 19009, 19103, 19104, 19105, 19222, 19223) is extremely like the Milwaukee stone in appearance. I quote from the report of the Wisconsin Geological Survey* the description which may be applied word for word to our rocks, of the Hamilton cement rock near Milwaukee, which occupies a limited area near the lake and immediately north of the city. "In general lithological characteristics, it consists of a bluish-gray or ash-colored, impure dolomite, which weathers, upon exposure, to a yellowish or buff color, owing to the oxidation of the iron which constitutes one of its ingredients. The impurities consist chiefly of silica and alumina. The rock is characterized in certain portions by the occasional presence of cavities in which occur crystals of pyrites and calcite, and, very rarely, zincblende. Crystals of the two former minerals are disseminated more or less through certain portions of the rock. In texture, it is somewhat varying, being quite homogeneous in some layers, and quite irregular and lumpy in others * * * In degree of induration, it ranges from rather soft to moderately hard. The beds are usually thick, with the exception of some portions, which are somewhat shaly." In the same report on the following page (p. 396) will be found a number of analyses of cement rock. See also Part I of this Volume. No analysis of the Soule rock has been made to our knowledge, but a bed similar in horizon near Grand Rapids analyzed by Rominger has a good analysis for hydraulic lime. In general it may be said that in a good hydraulic limestone there should be about 21% of insoluble matter classed as clay. This was told me by very successful manufacturers in Germany who were exporting their product to the United States and this agrees very closely with the proportions in the analyses of the Milwaukee rock. It must be remembered that common clay is largely finely divided silica (33%), with some hydrous silicate of alumina, so that most of the 21% will be silica. The percentage of carbonate of magnesia is generally considerably less than two-thirds that of carbonate of lime. Just at present, however, the manufacture of Portland cement, in which the exactly right ratios are obtained by mixing, is replacing that of rock cement.

Success in the manufacture of hydraulic cement means much more however, than merely finding a suitable stone. It means constant watchfulness, and continual analysis to secure a uniform composition, through grinding, and proper burning, and this is also true of Portland cement.

*Vol. II, p. 395.

§ 8. Coal.

The thickness of the principal seam is from four to two feet and less in the area of the coal basin, and above it there are indications of a thinner seam. It is at times cut off by sandstones as previously described. The depth is from 80 to 120 feet, and the deeper we find it the more likely it is to be thick. The water which is associated is a serious detriment, but as I have said, I do not think it comes from above. If I were working I should be careful to avoid sandstones, either above or below, but I had as lief work under the lake as not. In fact on some accounts I think that the coal might be thicker close to the lake to the southwest. All artesian wells like that at Oak Grove and the neighborhood for example, should, however, be cased off and avoided.* The main objection to the Sebewaing coal is its sulphur. The Sebewaing Coal Company say that their coal contains about 3% sulphur, and analyses of the product of the Saginaw Bay Coal Company are similar (Nos. 1 and 2 below).

	1.	2.
Moisture	4.46	4.82
Volatile carbon	47.92	44.58
Fixed carbon	40.45	41.52
Sulphur	3.06	3.38
Ash (probably mainly iron)	4.04	5.70
	99.93	100.00

Number	3.	3. Figured Dry.	4.
Location	Michigan Standard, Sebewaing.		
Sp. Gr.	1.34		
Moisture	6.09		41.39
Volatile Combustible.	39.59	42.20	
Fixed Carbon	46.06	49.00	50.28
Ash	8.26	8.80	8.33
Sum	100.000	100.000	100.000
Total S	5.72		5.80
S in ash	0.04		0.05
Volatile S	5.68	6.05	5.75
S from Fe			6.52
Fe			5.71
C	68.07	72.49	
H	5.26	5.61	
N	1.49	1.59	
O	5.15	5.48	
Obs. with Calorimeter. Calories of heating power	7,070	7,520	
" " " B. T. U	12,714	13,538	

1 and 2, Saginaw Bay Coal Co., Vol. V, p. 84.
3. By H. J. Williams.
4. By C. H. Hilton.
This coal yields a coke of small volume fairly well fused. It is a coking coal.
Sample taken by H. Ries.

Table IV. Tests of Sebewaing Coal.

*Since writing the above an artesian well has burst into the coal mine at Sebewaing, making much more pumping in 1899, and the Sebewaing Coal Co.'s mine has been drowned out.

Since in 100% of (marcasite) sulphide of iron there are 53.3% sulphur and 46.7% iron, if all the sulphur of analyses 1 and 2 comes from sulphide of iron there would have been 5.74 to 6.36% marcasite associated with the coal and the iron therefrom would when burned to $Fe^2 O^3$ make 3.82% to 4.23% of ash.

Plate IX. Glacial striæ at Bayport Quarry.

It is to be presumed that masses of solid "sulphur" or marcasite, such as often occur, were rejected, from analyses 1 and 2, as they are from the coal shipped. In the analysis of the Michigan Standard Coal above no such pains was taken, as the object was rather to get a fair sample of the coal seam as it occurred rather than as it was shipped. The marcasite if burned gives off much heat, and in fact it often catches fire spontaneously in the piles where the refuse to sulphurous coal is dumped. But while such coal makes a very hot steam coal (and tests have shown it to compare favorably with Ohio coals), the corrosive effect of the sulphurous fumes is disagreeable, making it unfit for gas making, passenger service, etc. The heating power measured in British Thermal Units, computed from the proximate analyses by the formula:

Heating power in B. T. U. = 146 (fixed carbon) + 147 (volatile carbon) + 40S would be: — 13,520 B. T. U. for No. 1; 13,210 B. T. U. for No. 2; and 12,767 B. T. U. for No. 3. This formula is an average one for Michigan coals. Kent's formula would give from the proximate analysis of No. 3 but 11,367 B. T. U. Dulong's formula would, however, from the ultimate analysis of No. 3 give 13,037 B. T. U. for the heating powder of the same. The Sebewaing coal runs higher in volatile carbon and hydrogen than the Saginaw coal, as well as in sulphur.

At one time in the Jackson mines the miners were paid five cents a ton more for the "sulphur" or marcasite than for the coal. This sulphur is used in acid making, and it might be used in a fertilizer factory, but as there is a great deal to be found elsewhere, it could hardly be exported far. The most promising way of utilizing it would be in connection with some local industry or bone factory.

The Saginaw Bay Coal Company was the earliest producer, but was closed down by water. The Sebewaing Coal Company was still at work when the report was written, but succumbed to the same difficulty February 27, 1899. Maps have not been kept, but from the recorded output, and what I could learn of the thickness and extent of the workings, I have constructed a dotted line which may show the area within which the workings probably lay in 1897, within which area caution should be observed as to sinking wells, or in advancing from any shafts hereafter to be opened. The field has been taken up by the Michigan Standard Coal and Mining Co., to whose manager, X. B. Konkel, we are indebted for information. The location of these properties is shown on Fig. 10. The Michigan Standard Coal and Mining Co. organized in October, 1898, and reached 4 feet 9 inches of coal at 92 feet depth on December 19, following. They have the coal rights for 300 acres which is said to be covered by 7 to 17 feet of hard slate roofing.

	Saginaw Bay Coal Company. W. L. Webber, Pres.	Sebewaing Coal Company. S. O. Fisher, Pres. W. T. Chappell, Sec. and Mgr.
1890	....	....
1891	10, 635	....
1892	16, 800	....
1893	13, 820	....
1894	....	38, 523

Table V. Statistics of coal production.

In 8 months of 1899 the Michigan Standard took out about 5,000 tons and are hoping to make it 20,000 in 1900.

The coal is used mainly by railroads and others, as steam coal, and the Dorrance grate is especially recommended for use with it since with so much sulphur it is bound to run on the grate. No attempt has been made to use the associated clays, the only thing of the sort having been the use of the refuse for mending the adjacent sandy roads, for which it is well adapted, nor has the associated sulphide of iron been used. For farther description of the coal basin see § 2 of Chapter II, § 5, of Chapter V, and the records of borings in Sec. 7, 8, 17 and 18 of T. 15 N., R. 9 E. These records we have leave to publish now as the coal lands are pretty well known, and the records throw light on the prospects for water, and for shale industries, pyrite, etc.

§ 9. Ores, sulphides of iron, zinc and lead.

(a). Sulphide of iron, pyrite and marcasite.

The metals are frequently associated with sulphur as sulphides in nature, and these sulphides are frequently mined. The sulphides of iron have never, however, been utilized as primarily sources of iron, but as sources of sulphur or rather sulphuric acid they have a certain value (about $4.00 to $6.00 a ton at factory). I have already mentioned that they occur with coal, and it is as a bye product of coal production that it is most likely that they will be of economic value. But they are by no means confined to the coal. They occur abundantly throughout the formation, nodules are common in the lower shales, and as already mentioned the sandstones of the Point aux Barques lighthouse are heavily charged with them. It is very common also to strike them in the wells, but from the nature of the case one cannot be sure whether the body struck is merely a nodule, i. e., irregular rounded mass, a form in which they frequently occur, or whether it is a more extensive bed. The top of the Napoleon sandstone is often heavily charged with sulphides of iron, and it will be noted that many of the wells around Tarry in Fairhaven township report considerable bodies of pyrite. The samples from these wells in Fairhaven township also show much pyrite. The sulphide of iron is likely to occur with the sulphides of zinc and lead, and when it does so occur it lowers the value of the others. The sulphide of iron must itself be quite pure to have any commercial demand.

(b). Sulphide of zinc, i. e., sphalerite, black jack or blende.

Small quantities of this mineral are very widely disseminated through limestone. It has a resinous lustre, good cleavage, and the powder has a dirty brown color, generally speaking. It is easily scratched with a knife. The lustre is so bright that a casual glance may not distinguish it from the sulphide of lead or galena, though they are easy enough to separate (p. 230). This mineral occurs in some quantity in limestones, probably of the Michigan series, in the adjoining county of Tuscola, near Cass City, and occurs as a mineralogical curiosity in Huron county (See Chapter VIII). Among the borings from Bauer's well, Sebewaing, I saw fragments from a cavity 118 feet down, i. e., near the top of the Bayport limestone, that showed specks of zinc blende.

(c). Sulphide of lead, galena.

This mineral has nearly the hardness and color of lead, but breaks into square angled pieces. At the time I was in Huron county there was quite an excitement as regards lead mining, and some explorations were carried on by Chas. Henning of Saginaw and others, with no success that I at present know. Since I made my examinations there have been reports of further explorations. The origin of the search for lead seems to be traditions of Indians finding it, so that it seems to be worth while to sift these traditions, and see what they are worth, and what the real prospects are.

The traditions all agree that the Indians went off into the woods and would not allow themselves to be followed, but came back with lead that they said they had obtained. Now as the reduction of lead from galena is extremely easy this is not intrinsically improbable. From Port Austin they are said to have been gone three or four days and the direction they look led people to think that the lead ore was obtained along the Pinnebog. From Heisterman's Island they are said to have gone across to the main land. There are numerous reports as to their having been offered large sums to reveal the place.

Dr. W. C. Wright of Unionville, gave me a piece of galena, which he obtained from an Indian halfbreed in the winter of 1888, who said it came either from near the Shebeon or from a place where the Au Sable River cut through the formation.

Before we speak of the Indians farther we will take into account a few other facts.

Around Mosner's hotel were a number of pieces of galena which were said to come from near Shebeon.

Mr. George Schuch is said to have found a piece of galena in digging a well 18 feet deep in the drift, on Sec. 21, T. 16 N., R. 9 E. Mr. Lambert of Caseville, said he picked up a chunk of galena as big as your fist near the mouth of the Shebeon, on Sec. 11, T. 16 N., R. 9 E. Some of the samples from Collison's well on Sec. 15, T. 16 N., R. 9 E., show galena. (See record.)

Finally, I have seen a piece of lead, not lead ore, which was said to have come from a test-boring. This may have come thence, but must have been put there first. It is easy enough, not merely for the driller, but for any mischievous boy or anyone else, in any way interested, to drop something down a drill hole. We have therefore to take the evidence of churn-drill powder with caution. So, too, an Indian might be tempted to "fill up" an interviewer, especially if he thought the compliment might be returned and he himself filled up. Such a tale as that an Indian off hunting struck his tomahawk into an apparent stump to hold it, while skinning game, only to find a solid mass of lead, betrays itself as a work of overbold imagination.

But on the other hand we must consider that the reports unite in directing suspicion on the same formation, the Grand Rapids group,—the Upper Mississippian,—the reports being without collusion, and by persons unacquainted with the geology, and that the samples of galena agree physically, being of the coarsely cleavable variety. When we consider, too, that zincblende, which is a common associate of galena is known to occur in this formation, and that the Upper Mississippian itself is in Missouri and elsewhere a well known producer of galena* we have a strong presumption that the Grand Rapids group is in Michigan also somewhat galeniferous. But in searching for deposits we must remember that Indians rarely if ever, mined, certainly never test-pitted, and what galena they may have obtained was almost certainly obtained from the surface. Again an Indian's time was worth very little, especially if in a congenial occupation. It is quite as likely as not, therefore, that they obtained their galena from the beds of streams or other surface deposits where experience had taught them it was to be obtained. Mr. Lambert's discovery and the Collison well samples, taken in connection with the fact that the Shebeon does cut down to the limestone, make that region, i. e., that colored on the map, PI. VII, as underlain by the Michigan series or higher beds the most promising, but the plan of investigation which would commend itself to me would be that of panning, as the western miners do for gold, and seeing if the heavy residue at the bottom of such a pan showed signs of galena or rather of the heavy white carbonate into which it would be converted. At the same time it would be little extra trouble to watch the sand pump when a well is bored for water in the district most likely to show signs of galena, and perhaps sometime a well put down for water may show signs of galena sufficient to warrant the use of a core drill. I do not consider that the prospects of a paying lead mine warrant expensive exploration, or borings, for the express purpose of discovering lead, for the chances are decidedly that all the lead that has been discovered conies from pockets of no economic value. But any farmer's boy can do the panning suggested, and if the lower Shebon, Pigeon or lower Pinnebog gravels showed uniformly a considerable percentage of lead ore, the prospects for success would be improved. It is possible that the fissure which we have spoken of as cutting the Sebewaing coal mine, which seems to have concentrated the sulphide of iron along it, may lower down, where it passes through the limestone, have served as a channel for waters which may there have deposited the other sulphides. And so the fault suggested by Mr. Wallace on Sec. 14, T. 16 N., R. 9 E., if it exists even as a mere break, may serve equally as a channel for the waters which concentrate ore bodies.

*Missouri Geol. Sur., VI, pp. 47, 150, 151, 157, 158, etc.

§ 10. Salt.

This was once a great industry and went hand in hand with the lumber industry, and as the one has declined, so has the other. The lumbermen are largely dispersed to Alabama, Minnesota, all over the United States, and the salt blocks are shut down. Only around Caseville, and around Owendale, does the lumber industry still linger. There was still quite a nice little area of pine to the east of Caseville, and some comes in from the south around Owendale. Flach and Conley of Caseville, have the only remaining salt blocks in operation in the county, when once there were over ten.

We give below a list of the companies, so far as we know, that have operated in the county. Up to 1887 Huron county produced about ten per cent of the product of the state. In the last decade it has dwindled to a mere local supply. We have endeavored to get the product more precisely, but have not been able to. The reports of the commissioners of mineral statistics have some misprints that we cannot straighten out.

The analyses of Chapter VI, p. 135, show the chemical nature of the brines. It will be noticed that the deep Harbor Beach well has a much larger proportion of other ingredients to the Na Cl (pure salt) than the brines from the Berea grit. This is also true comparing it with the shallower well at Harbor Beach, in which the Na Cl is over 98% of the solids (analysis 4). Though the wells at Caseville have not been analyzed, so far as known, a similar condition is indicated by the fact that Crawford's deepest well, which went down below the Berea grit and corresponds more or less therefore to the deeper Harbor Beach well, gave a brine so much more impure that they had to wash the pans every 24 hours, and later every 12 hours, to get rid of the bittern (which contains the chlorides of lime, potash and magnesia), whereas before, i. e., when it was only 1700-1800 feet deep, such washing was necessary only every 48 hours.

	Date.	Depths	Capacity.	Process.	
Tremain & Clark, Old Bayport, never in operation	1874	2,000	....	....	....
Frank Crawford, Caseville	....	(1)	....	....	....
		1,760	....	....	....
		(2)	30,000	steam	....
		(3)	....	....	....
		2,270	....	+pan	....
Pigeon River Furnace Co., (later Lake Huron Iron Company)	....	1,760	30,000	steam	3
Flach & Conley (formerly Curran, Flach & Conley)	....	1,800	....	steam	6
Williams, Eakins & Soule, Port Crescent	....	1,250	....	....	....
N. B. Haskell, Port Crescent	....	....	....	....	....
Ayres & Co., Port Austin	1863	1,198	20,000	pan	....
Ayres, Learned & Ayers (Skene well)	1875	1,226	....	pan	....
M. Carrington, Port Austin	....	1,200	....	pan	....
? Grindstone City	(1)	1,000 ?	....	....	....
	(2)	?	....	....	....
New River Salt Co., New River	....	1,029	15,000	pan	3
Port Hope Salt Co., (R. C. Ogilvie)	....	787	20,000	pan	3
S. Jenks & Co., Harbor Beach	(1)	715 or 702 or 900	20,000 to 50,000	pan later steam	3
Huron Dairy Salt Co., 1886	(2)	1,920	....	....	....
Thomson & Bro., White Rock	(1)	555	20,000	pan	6
	(2)	700	....	....	....
	(3)	1,311	....	....	....

Table VI. Statistics of the salt wells.

It will be noticed how comparatively free these deep brines are from sulphates. Now Leipprandt's 100 foot well, on Sec. 13, T. 17 N., R. 10 E.), which was quite salt and has been used for making salt for domestic use, and is said to make a pure salt though it needs to stand in the sun for a day to get rid of the iron (this is necessary for all brines), gives a strong reaction for gypsum, and this is characteristic of all the shallow salt wells.

In view of the vast fields of rock salt that have been discovered elsewhere in Michigan, which though they probably underlie Huron county, are many feet deeper than the deepest well, and in view also of the departure of the lumber industry, it is not to be expected that there will be any great revival of the salt industry. At the same time it will probably continue to supply a local demand unless crushed by some large association. The surplus is shipped outside, but the profits come from the local trade. Nothing has been done yet toward saving the by-products, the plaster and bitterns, and it is in that direction we must look for progress in the future. I have already suggested that there might be enough bromine and potash in some of the bitterns to pay for extraction, and it seems as though some of the bitterns might find uses as a base for disinfectant manufacture, etc. The calcium chloride has been used in putting up canned fruit, and the county is an admirable fruit raising country. It is also used with water glass in making artificial stone.

The use of the refuse salts as fertilizers has a limit in this county owing to the fact that in the western part the soil is already rich in the same substances, but on the sandy strips, and in connection with manufacture of bone fertilizer and the use of the sulphur of the mines, there seems to be an opening for their use.

§ 11. Gypsum, or plaster of Paris.

This mineral is white when pure enough to be valuable and cleaves into scales of transparent friable flakes. It is soft enough to scratch with the finger nail.

Just across Saginaw Bay the gypsum quarries of Alabaster and Tawas Bay have long been known, but while it has early been observed by Rominger that the strata ought to extend into Huron county, but little has been known definitely in the matter. Here and there wells were supposed to have encountered gypsum, but drillers are likely to overlook it, when not going down to find it.

The work of the survey has put it beyond question that at least one considerable bed of gypsum does extend into the county and its probable extent is shown by a line upon Plate VII*, but it is nowhere exposed at surface. The few fragments of gypsum we have seen (Sps. 19004 and 19159) only show that there is some of good quality, but what the thickness of any certain grade may be, we do not know. So far as we can judge, it is everywhere covered too deep to permit of working by stripping and open quarrying but the southern part of Sec. 23, Chandler, and the neighborhood of Tarry near the center of Fairhaven, seem as good places to test as any. There has been quite an inquiry for plaster lands lately, but in view of other deposits, better known and quite as well located, the prospects are not too flattering. At the same time I doubt not that some time this resource of the county will be developed, when the prospects for pecuniary success are favorable, and it is certainly advisable that in all well-drilling throughout the district where the gypsum is liable to occur as shown on the map (Plate VII) an eye should be kept out for it, and as good samples as possible kept, as well as an idea of its thickness got, for its own sake, as well as to keep it out of the water.

*See above Chap. V, § 3, pp. 100 to 103.

§ 12. Marl.

Marl or rather bog lime is a white or bluish gray substance slimy and sticky when wet, powdering when dry, which effervesces violently and dissolves largely in acids, and is found beneath lakes, ponds or marshes, and is often full of little shells, such as those listed in Chapter 10, § 2. Generally speaking, throughout the state the well and ground water contains considerable lime dissolved in the water as bi-carbonate. When this water finds its way by springs into ponds or marshes the carbon dioxide may be abstracted by plants (Davis), or sometimes escape directly, and carbonate of lime may be extracted by animals or precipitated directly if the loss of carbon dioxide to the vegetation or the atmosphere is sufficiently great.

It has long been recognized as a fertilizer, but usually the solids of Huron county have sufficient lime and its main application will be upon very sandy or sour soils. As a fertilizer no great purity is required and in fact most dictionaries refer to marl as a calcareous clay.

A new and important use for it has, however, sprung up in the manufacture of Portland cement. For this purpose it is wanted to be as pure $CaCO_3$ as possible, so that just the right proportions of clay can be added to it to make the best composition. Practically the dry marl should be not less than 9-10 $CaCO_3$. I have seen no marl as pure as this, but there are signs of the presence of marl in the marshes back of the Forest Beaches from Mud Lake to just south of Badaxe, and clear around to Ruth. It might be well to explore farther, as if there were much marl, especially just north of Ruth it could be worked in connection with the shale banks of White Rock.

Some other localities for marl are mentioned in the reports of various wells e. g. § 20, Hume township.

CHAPTER VIII. NOTES ON MINERALS.

§ 1. Introduction.

It is the object in this chapter to gather together notes on the minerals as such. The mineralogy of the county, if we leave out of account the minerals that may occur in the drift, is very simple, and it would be possible to make it quite complete. But I have thought it would add to the utility of the report to the residents of the county, if I added few notes on the minerals which make up the rocks that are scattered as boulders upon the surface. As we made no extensive observations upon the drift, and almost any mineral rock or fossil that occurs in Canada or the whole lake basin is liable to turn up, transported here by the ice of the glacial sheet, or of the spring floes that drift here and there as the winds impel, this part of the work is very incomplete. I have arranged the work in this way. I have given each mineral a heading, taking them in the order in which they occur in Dana's mineralogy, and then taking each variety or different form of occurrence, have given briefly such characters as have actually been observed on Huron county specimens, and then appended the locations where the same were found.

§ 2. List of minerals.

Copper.—Copper-colored; can be cut, has a shining streak, tarnishes dark, and is likely to have greenish spots.

Mr. W. L. Webber has a piece about two ounces in weight which was found at the bottom of the stripping on top of the rock at the Bayport quarry. The stripping is of lake gravel, a water stage just above Lake Algonquin. The connection by water through to Lake Superior at this time is suggested. Label: "received March 10, 1887, from A. H. Wallace." The crystals of native copper referred to by Winchell (1860, p. 80) have not been verified.

Galenite. Pb. 86.6%, S., 13.4%. Lead-colored, metallic, easily cut, heavy, brittle, breaking into cubical pieces, weathers so as to have a yellow coating. The occurrences have already been described in Chapter VII § 9 (c). None of them are satisfactorily authenticated, that is, there is no place where one can go back and be sure of finding even a very little galena. All of the finds may have been from drift deposits, except that in Collison's well. Galenite is most liable to be found in small vugs or cavities in the limestone.

Sphalerite. (Zn 67%; S. 33%). Lustre resinous to almost metallic; color deep yellow to black; very cleavable, the directions of cleavage being at angles of 60° streak rather dirty.

Found in the drillings from Bauer's well at Sebewaing; also (Sp. No. 19066) traces near the Point aux Barques lighthouse, with cal-cite replacing a shell; liable to occur under same conditions as galena.

Chalcopyrite? Cu 34.5%; Fe 30.5%; S. 35.0%. At the Point aux Barques lighthouse some of the pyritic matter seems from the copper blue-green weathering stains to show traces of copper, but the mineral as such has not been recognized.

Pyrite. Fe 46.6%; S. 53.4%. Brassy; in cubes or pentagonal dodecahedra, harder than a knife but brittle; powder greenish to brownish black; less decomposed and somewhat more yellow than marcasite, but also weathers fairly readily to sulphate of iron, or to hematite, in which case the rocks containing it smell sour and taste puckery. While pyritic matter is common in all the formations it is generally of the allied species, marcasite, which has exactly the same chemical composition but a different crystalline form, a lighter color and a greater readiness to change to sulphates. At the same time the two seem to be often intimately associated. I have pieces of coal in which marcasite seems rapidly to change to vitriol, while pyritic coatings on the faces near by remain untouched. Occasionally it occurs in vugs in the sandstone (Sp. 19011) in quite good sized crystals.

Marcasite. Like pyrite, but differing in crystalline form, and more readily decomposed. Some of the specimens appear very white on fracture, which suggests a trace of arsenic.

Abundant in the coal mines of Sebewaing, occasional in the lime-stones of Bayport, etc. Abundant in the shales in nodules and especially so at the Point aux Barques lighthouse, sometimes cementing the conglomerate.

Quartz. Si 46.7%, O 53.3%. Rock crystal, etc. This is the principal constituent of sand, and makes most of the pebbles of the conglomerates and gravels, and is most abundant in the boulders, and, is usually either colorless, transparent, or white and milky. It is the hardest mineral commonly met, and a steel knife will leave a metallic streak on it, and there is almost no trace of cleavage, the fracture being commonly glassy. When crystallized, it has the form of a hexagonal prism with triangular faces making the termination. In this form it occurs in the nodules of Charity Island (Sp. 19191), but is absent or rare around Bayport in the nodules, though many of the fossils and corals are composed of quartz.

Chalcedony. A variety of quartz, with a waxy lustre, and bluish to white tints, tending to have a botryoidal surface (composed of little round projections like a bunch of grapes or raspberries). Most abundant at Charity Island (Sp. 19191), and liable to occur elsewhere in the limestone.

Chert. Opaque gray silicious nodules, with a smooth conchoidal fracture and somewhat splintery, often tending to weather out into concentric shells. Occurs in the limestone (Sps. 19002, 19179).

Hematite. Fe 70%; O 30%: Red to steel-color; powder red. Occurs abundantly in the drift, associated with and coloring the blood red jasper which is so showy a constituent. It probably occurs at times as an alteration product of iron sulphides, but generally the mineral that results from these is limonitic, i. e., hydrous. Only once have I observed well developed hematite (Sp. 19020), near Hard Wood Point, lining a cavity. The bright metallic scales are arranged perpendicular to the walls of the cavity as in the specimens of grape ore that show a bloom.

The Lower Marshall sandstone is heavily charged with iron. Probably originally much was carbonate, but many of the flag layers have a blue or purplish color and give a red streak, showing that they are charged with hematite. Others are more altered and give the yellowish streak of limonite. (Sps. 19037, 19125, 19137, 19145.)

Limonite. Fe 59.8%; O3 25.7%; H_2O 14.5%, Ochre and bog iron ore. Wide spread as iron rust, staining and coloring the soil and rocks. Davis has noticed that around the borders of bogs it is leached out of the sand by organic matter, to be deposited at the bottom. Specimen 19174 of bog iron ore shows the effect very characteristically. There are bright irregular seams which look like black varnish, yet give a yellow, brown powder, embedded in a yellow brown ochre. The Marshall sandstones are often very heavily charged with limonite. Sometimes a concentric structure can be noticed, the original green or blue shale lying in the middle, while there are brown lines around it as the weathering to limonite works in (Sps. 19089—19094, 19069).

Wad. Impure ore of manganese. Specimen 19174 gives no reaction for manganese, but Sp. 19158, which is probably from Tuscola county and is a blue black earth with calcareous pebbles, does. Similar deposits might be expected near Soule.

Calcite. CaO 56.0%; CO_2 44.0%. Effervesces in vinegar; soft, being readily cut with a knife but not with the finger nail; cleaves readily into small rhombs with faces making an angle of about 75° with each other. Crystallized it occurs best developed in vugs or in nodules in the Bayport limestone (Sps. 19002 and 19005). In these cavities there are two forms side by side which look different enough to be different species: (1) Dogtooth spar, in small white pointed scalenohedrons; (2) Generally older, more transparent but brownish crystals, in which 2R is the predominant face, though a number of other faces, and a twinning also appear. These crystals from their brown color and occasionally iridescent tarnish would be taken at first for some other carbonate, but in reactions with acids and in specific gravity they agree with calcite, and not with the magnesian or ferriferous carbonates, so that the different appearance must be due to a trifling percentage of impurity (organic matter ?).

Calcite also occurs quite commonly in small crystals lining the cavities of fossils, especially in the chambers of Goniatites (Sp. 19010 and 19018).

Calcareous tufa, a recent deposit of calcareous springs, looks at first glance more like old bone than anything else (Sp. 19107). In a massive form calcite composes the limestones, and limestone pebbles are widespread through the drift. The outcrops of limestone have already been described.

The other carbonates, now that what I took to be ankerite proves not to be such, have not been recognized in crystalline form, though dolomite doubtless exists as does certainly the massive form.

Dolomite. CaO 30.4%; MgO 21.8%; CO2 47.8%. Less briskly attacked by acids than calcite and slightly heavier; similar in cleavage and hardness. Certain beds in the Bayport limestones are decidedly dolomitic. Generally such beds are darker and browner.

Spherosiderite. Fe 48.3%; O 13.8%; CO_2 37.9%. Concretionary iron ore, characteristic of the Lower Marshall, forming balls which turn to limonite on exposure, always more or less impure and acting as a cement to the sand. Specimen 19011 shows the balls well, but many others of the Lower Marshall specimens effervesce slowly with acids, rapidly coloring the acid yellow.

Feldspars. Alumo-silicates of potash, soda, and lime, not quite as hard as quartz, generally white or light colored, with two cleavages which are not equally good and are at nearly right angles. Common among the drift pebbles, making with quartz the principal constituent of the granitic rocks. In the conglomerates it seems often to have changed to kaolin, and yet sometimes the feldspar is fresh enough so that the cleavage facets show well.

Pyroxene group, found in the drift only, in dark colored boulders.

Amphibole, or hornblende. Silicates containing alumina and magnesia, and usually iron, lime and a little soda.

A common, perhaps the commonest dark constituent of the boulders, usually dark green, giving a light powder, and showing a prismatic cleavage; gives a somewhat silky lustre when closely examined.

Garnet. Silicates of alumina, lime, and, in usually less quantities, of lime, magnesia and iron.

In small pink granules this is a common constituent of sand, and occurs in the drift formation. It is more marked in the residue left by panning.

Epidote. A silicate containing lime, iron, alumina and water; green to yellow-green, only in the drift, or in sand as yellow-green grains?

Mica. Silicates, containing alumina, water, and potash and soda or magnesia and iron, the darker ferriferous ones being often group-ed as biotites and the lighter as muscovites.

Usually in thin flexible white or brown, silvery or golden scales well known as isinglass, sometimes mistaken for gold! The shales of the Marshall are generally exceedingly rich in mica, and scales of white mica (muscovite) may often be seen in the grindstones. The shales below the Marshall are even richer in mica, and the shales below the limestones at Soule are also micaceous. With quartz and feldspar it occurs in the granite boulders.

Also occurs in boulders of mica schist, etc., and with staurolite in staurolite schist.

Staurolite. (A silicate of alumina, magnesia, iron and water.) Occurs in prismatic crystals with an obtuse prism in front, frequently twinned so as to look like a St. Andrew's cross; scattered here and there on a fine grained micaceous ground in a staurolite schist in occasional boulders, as on North Island.

Chlorite. Silicates of alumina, magnesia and water, in green, flexible, not elastic scales in boulders. There are characteristic green stains in some of the limestones that seem to be due to some chloritic mineral.

Kaolin. Hydrous silicate of alumina. White; earthy smell; sticks to the tongue, soft; occurs after feldspar in rounded nodules in conglomerate (Sp. 19016).

Gypsum. CaO 32.5%; SO_3 46.6%; H_2O 20.9%. Cleaves into white brittle scales; soft, just scratched with the finger nail. In small crystals sharply formed like Fig. 1, under gypsum in Dana's System of Mineralogy, on shales in the Sebewaing coal mines, probably due the evaporation of the selenitic (gypsum-bearing) waters (Sp. 19233). A piece from Sec. 16, Caseville, probably found in digging a well is satin-spar, with a satin-lustre, being an aggregate of parallel fibrous crystals (Sp. 19159).

Large rounded masses are found elsewhere in the drift digging wells. Being more or less soluble, it cannot remain very long exposed at the surface.

Melanterite. FeO 25.9%; SO_3 28.8%; H_2O 45.3%. In fibrous needles radiating from pyritic specimens of coal or marcasite; has an inky taste.

Occurs very abundantly on the specimens from the Sebewaing coal mine and probably occurs elsewhere on the nodules of iron sulphide. Another yellow iron sulphate, either copiapite or coquimbite, also occurs in similar circumstances.

Coal. Impure carbon; occurs both in the coal mines and in small pockets or coaly bits and fossils at various points in the Marshall series. The quarries generally show some slabs sprinkled with coaly bits. (Sp. 19015.)

One interesting occurrence already mentioned is that of a rounded pebble of bituminous coal in the conglomerate of Point aux Barques lighthouse (Sp. 19068).

The coal will generally differ from black shale by leaving, after it ceases to burn with a yellow smoky flame, a black residue which a lens shows to be full of bubbles, indicating that it has been melted. In any case if it is burned so that the residue ceases to be black, it will not amount to more than 20% of the whole. In black shale on the other hand the residue is apt not to be black, will retain the original shape of the fragment and be more than one-fifth of it in weight.

CHAPTER IX. BOTANICAL NOTES, BY C. A. DAVIS.

§ 1. Geological, geographical, and practical relations of plant distribution.

The following list of plants is based on collections and notes made at odd moments and incidental to regular geological work, and entirely subordinate to it. The larger part of the work upon which it is based was done at Port Austin, outside regular hours of work. Moreover the territory assigned the writer for examination was a strip three townships wide through the center of the county and no study was made of the flora of the eastern or western sides except such as could be undertaken in a day at Harbor Beach in July and a few hours at Caseville and Bayport, late in August, hence the list must of necessity be incomplete and fragmentary and is published without any pretense of being complete.

It is, however, true that the sections of Huron county visited by the writer indicate that its flora is not very extensive or varied, as a large part of the county presents very nearly uniform conditions of soil and elevation^ so that large areas are covered with a growth of practically identical species. The monotony of the vegetation is farther increased by the fact that a very large portion of the county has been devastated a number of times by fires, which have not only destroyed the primitive vegetation of the time when the fires occurred, but much of the vegetable mold as well, and with it the seeds and underground parts of the plants which might have survived the fires. As a result, these areas have been covered with a growth of such plants as could grow in rather thin light soil and whose seeds could reach the ground from a distance. Such areas must be seeded in two principal ways, by the winds and by animals, and of these two agencies, by far the most important is the wind. Hence we should expect to find those plants prevailing, whose seeds are easily carried by the wind, or whose fruits are attractive to animals, especially to birds. The woody plants whose seeds are capable of being borne long distances by winds are best represented by the poplars and willows, and of the herbaceous plants whose seeds are thus carried about, the common fire-weed, milk-weed arid thistles are excellent examples. Plants whose fruits are attractive to birds are well represented by the wild cherries, various berries, etc. If we examine the tracts of Huron county which suffered most from the great fires, we will find that the flora is almost wholly limited to those species whose seeds have been planted in the ways mentioned. The trees are various species of poplars, sometimes mixed with birches, the shrubs, blackberry and raspberry bushes, and the herbaceous species are represented largely by such forms as Epilobium, Solidago, Aster and others whose seeds are easily borne about by the wind. Plants whose seeds are less easily carried about from place to place are rare or wanting in such tracts, wherever they are found, and in the region under consideration there are whole sections whose entire flora does not exceed twenty or thirty species, except in the stream valleys, where the fires did not burn so vigorously, or info which seeds have been carried from unburned districts by the stream.

Still another consideration limits the productiveness of such areas as those above described, namely, that the soil is capable of supporting only a limited number of individuals of any species, and those species which can best endure the hard conditions imposed upon them will occupy the entire soil and prevent the introduction of less resistant forms. In places where supplies of moisture and mineral food are limited as they are over much of this county, each plant has also to cover relatively a large area with its roots, hence the number of individuals is small as well as the number of species, and vegetation is not luxuriant.

Of the entire territory visited by the writer, the region along the shores of the Lake and covered by the sand dunes showed the least change either from fire or from cultivation and hence was of most interest. Here the conditions producing scant vegetation are intensified to such an extent that herbaceous vegetation is reduced to the minimum and the ground is covered only by such forms of plants as have especially developed powers of resistance. These powers may develop along several lines, but chiefly they seem to be confined to increasing the moisture-absorbing or root system and decreasing the moisture-exhausting or leaf system. Or, as in certain species, the vegetative processes may go on actively only during the cool moist portion of the year, the plant remaining nearly dormant during the hot dry summer months, or living on reserve food stored in some specially adapted part of the plant. Because of these modifications to fit the special environment, the plants of the dunes are of great interest to the botanist and are worthy of farther study. The flora of the dunes of Huron county is made up of: (1) plants peculiar to the shores of the Great Lakes; (2) those common to the shores of the Great Lakes and of the ocean; (3) those found on sand barrens generally; (4) those which have been introduced by the advent of white men; (5) northern species. The limits of the various groups are quite well marked and may be defined as follows: The plants peculiar to the shores of the lake and ocean are to be found only near the water, probably not much out of the range of the highest storm waves, and so far as observed in this county, never beyond the dune line nearest the lake or the most northern one. The sand-barren plants occupy the rest of the dunes, encroaching on the territory of the other groups frequently. The fourth class take up unoccupied portions of the land wherever they gain foothold. The northern species are found on the more exposed situations along the dunes.

A problem worthy of solution is that involved in the fact that a number of species of the shores of the Great Lakes are identical with those found in similar places by the Atlantic.

The formerly accepted theory that the plants growing along the lakes are survivals from the time when the lake was an arm of the sea, is no longer tenable in the light of modern investigations. The species from the two regions are absolutely identical and of comparatively modern and highly developed types, and must have attained their present forms long after all connection between the ocean and the lakes which would admit the passage of salt water had ceased. Moreover, these species when found on the sea shore are not usually found on soil that is saturated with salt water, as the salt marshes are, but on the contrary, are found growing on the sandy strip back of the beach, or, more frequently, on sand dunes. If the salt water ever reaches these situations, the salt is soon leached out from the porous sand by rains and the soil is practically as free from salt as on the dunes of the shores of the Great Lakes.

It would seem probable that these plants are capable of enduring the exceptionally unfavorable conditions under which they must establish themselves from the seed, with greater powers of resistance than other plants. These conditions in part would be exceptional sterility of soil, for on newly formed dunes there is scarcely a trace of organic matter, and soluble mineral matter must be present in very small proportion, since the sand of both lake and ocean dunes is largely composed of silica or quartz. A second condition is exceptional mobility of the soil. Even in a slight wind, dune sand is in some motion and under stronger gales it blows about, even when the rain is falling, to such an extent that a plant may be buried out of sight, or have nearly all the soil removed from around its roots in a short time. A third condition is the great porosity of the soil, which makes it almost impossible for water to stay in it at all, especially near the surface. But few plants would be capable of enduring one of these difficulties, and undoubtedly many an ambitious weed perishes in the attempt to place itself among the plants which can get a foot hold despite all of them. When once established from seed the shore plants are vigorous, growing plants sending strong, wide-spreading roots deep into the soil and searching far and wide for food. The beach pea, *Lathyrus maritimus*, for instance, has been known to send its underground stem more than ten feet through the sand horizontally, and the tough thickly matted roots or rootstocks of some of the dune grasses make the best possible protection for the sand against the wind. So well is this recognized in regions where the wind moves the sand from exposed dunes to cultivated tracts, as for instance, on the shores of Cape Cod in Massachusetts, that stringent laws are enacted against breaking the sod on those dunes where these grasses have become established, and the inhabitants devote a certain season each year to planting the grasses on threatening dunes, to prevent the drifting of the sand.

As to the way in which the seeds of the plants growing on both lake and ocean shores traveled across the intervening land, it may be stated that migratory birds carry seeds of plants long distances, and this is particularly true of water fowl and wading birds, who carry seeds attached to beaks, feet and feathers, in considerable numbers, and migrate freely from the ocean to the lakes.

In general the flora of Huron county is most closely allied to that of the Saginaw valley, not a single species which is characteristic of the flora of the southeastern section of the state having been noted. Certain northern species are abundant enough to warrant the assumption that a portion of the flora has come from the northern shore of the bay, or across the Jake from the Canadian shore. This is easily explained when we remember that the migration of birds southward along the shore occurs at the time when the seeds of many plants are fully ripe and most abundant while the migration to the north occurs at a time least favorable for the transportation of seeds. The prevailing winds are also from northerly directions during the fall and it is quite certain as has been shown that they have much to do with scattering the seeds of certain types of plants. The evidence, geologically speaking, is that the lake currents run northward, not southward, along the shore of the county, and this taken in connection with the facts already pointed out in regard to the distribution of plants in the county would lead to the conclusion that such currents have little to do with carrying plant seeds. In this instance, however, the general law that such currents are important agents in distribution of plants is modified by the fact that only a few small and unimportant streams enter Lake Huron at its southern end, hence but small numbers of seeds are carried from the land into the lakes.

The importance of the wind as an agent of seed planting in isolated tracts of land is shown by the fact that Gull Island, a small tract of lake bottom exposed, near Port Austin lighthouse, by the late subsidence of the lake level, is covered with plants whose seeds are known to be disseminated by wind, only two species of a score or more noted, at the time of the writer's visit there, not being of this type.

The examination of the flora of Huron county made by the writer indicates climatic conditions which make possible the raising of nearly all the fruits which can be grown in the state, and the soil in many parts of the county is undoubtedly suitable for profitably raising all kinds of small fruits. Because of the northern location the ripening of these fruits is delayed beyond the season in the more southern counties and there should be a good demand for these late ripened fruits in the large cities. During the summer of 1896 there was a very large crop of fruits of all kinds in the older parts of the county and fruit trees of all sorts were thrifty and seemed unusually free from insect or plant parasites. The chief difficulties in the way of growing the more perishable fruits seem to be remoteness from markets and lack of cheap transportation, the latter especially.

§ 2. List of plants.

The nomenclature of the list here presented is that of Gray's manual, 6th edition, following for ease of comparison and the sake of those most likely to wish to use it, the order as given in Beal and Wheeler's Michigan Flora. From the fact also that Gray's Manual of Botany is still and must be for some time to come the most accessible work on systematic botany for students in the region covered by this list, this has seemed to be the wisest course to pursue in a list of this character.*

In conclusion the writer wishes to acknowledge the kindness of Prof. Charles F. Wheeler of the Michigan State Agricultural College, who has verified all doubtful determinations of species and rendered other valuable aid.

*A few unimportant divergencies from the order of Beal and Wheeler's flora noted in proof reading have not been corrected. Thus the following numbers should change places: 17 and 19, 48 and 49, 54 and 55, 224 and 225, 267 and 268, 281 and 282, 309 and 310. No. 30 should come before 35, 181 before 179, 183 after 185 and there are no entries 139 and 264. L.

LIST OF PLANTS.

1. Anemone cylindrica, Gray. Longfruited anemone. Sandy pasture on the Lake shore west of Port Austin.
2. Anemone Pennsylvanica, L. Pennsylvania anemone. Low ground along streams.
3. Ranunculus sceleratus, L. Cursed crowfoot. Near a spring 2 miles west of Grindstone City.
4. Nymphæa reniformis, DC. Pond-lily. Tuber-bearing water-lily. Pinnebog River in Hume township.
5. Nuphar advena. Alton, f. Yellow Pond-lily. Cow Lily. Common in streams.
6. Adlumia cirrhosa. Raf. Climbing Fumitory, Mountain Fringe. At the quarries, Grindstone City, on refuse piles. Also in talus of cliffs three miles west of that place.
7. Arabis lyrata. L. Common on the sand dunes along the lake.
8. Erysimum cheiranthoides, L. Worm-seed mustard. Near Port Austin on dunes.
9. Cakile Americana, Nutt. American Sea Rocket. Sand dune line nearest the lake. Not observed back of the outer row of dunes, and usually on the side facing the lake.
10. Saponaria officinalis, L. Bouncing Bet, Soapwort. Roadsides about Port Austin.
11. Silene antirrhina, L. Sleepy Catchfly. Sand dunes west of Port Crescent.
12. Silene noctiflora, L. Night flowering Catch-fly. Port Austin.
13. Lychnis Coronaria, L. Mullein Pink. Waste places, Port Austin.
14. Arenaria serpyllifolia, L. Thyme-leaved sandwort. Near Port Austin in barren sands.
15. Hypericum perforatum, L. Common St. John's Wort. Dry soil by roadsides near Port Austin.
16. Hypericum Canadense, L., var. majus, Gray. Crevices in the rocks on the lake shore near Port Austin.
17. Malva moschata, L. Musk-Mallow. Roadsides, frequent.
18. Malva sylvestris, L. High Mallow. Port Austin.
19. Malva rotundifolia, L. Common Mallow. Roadsides and waste places.
20. Tilia Americana, L. Basswood. Linden. Woods near Port Austin.
21. Geranium Robertianum, L. Herb-Robert. Along the Beach near Grindstone, also in rocky soil inland.
22. Impatiens fulva, Nutt. Spotted Touch-me-not, Jewel-weed. Low grounds.
23. Oxalis corniculata, L., var. stricta, Say. Yellow oxalis. Wood-sorrel. Common.
24. Xanthoxylum Americanum, Mill. Prickly Ash. Common in moist soils.
25. Vitis riparia, Michx. Wild or Fox-grape. Frost grape. Common along streams.
26. Ampelopsis quinquefolia, Michx. Woodbine, Virginian Creeper. Woods, Common.
27. Acer saccharinum, Wang. Hard maple, Sugar or rock-maple.
28. Acer dasycarpum, Ehrh. White Maple, Soft Maple. Low ground along streams.
29. Acer rubrum, L. Red Maple, Soft Maple. Moist woods.
30. Trifolium pratense. L. Red Clover. Roadsides and fields.
31. Rhus typhina, L. Stag-horn Sumach. Common.
32. Rhus copallina, L. Dwarf Sumach. Sand dunes.
33. Rhus Toxicodendron, L. Poison Ivy, Poison Oak. Common in rocky places, and in the moist places among sand dunes.
34. Rhus venenata, DC. Poison Sumach or Dogwood. In swamp about Mud Lake, Grant township.
35. Trifolium repens, L. White Clover. Pastures, etc., common.
36. Melilotus alba, Lam. Sweet Clover. Waste places, Port Austin.
37. Robinia Pseudacacia, L. Locust. Port Austin, Huron City, Etc.
38. Desmodium Canadense, DC. Tick-Trefoil. North Charity Island.

39. Lespedeza capitata, Michx. Bush Clover. North Charity Island.

40. Lathyrus maritimus, Bigelow. Beach pea. Beach at Port Austin.

41. Prunus Americana, Marshall. Wild Plum. Hume township, along streams.

42. Prunus pumila, L. Dwarf Cherry, Sand Cherry. Abundant on the dunes west of Port Crescent.

43. Prunus Pennsylvania, L. Wild Red Cherry. Common.

44. Prunus Virginiana, L. Choke Cherry. Common on the sand dunes west of Port Crescent.

45. Spirea salicifolia, L. Meadow Sweet. Low grounds, common.

46. Rubus strigosus, Michx. Wild Red Raspberry. Common.

47. Rubus villosus, Aiton. High Blackberry. Common.

48. Rubus hispidus, L. Running Swamp Blackberry. Common on the sand dunes.

49. Rubus Canadensis, L. Running Blackberry. Dewberry. Rocky places.

50. Fragaria Virginiana, Mill. Strawberry. Common.

51. Fragaria vesca, L. Strawberry. Woods common.

52. Potentilla Norvegica, L. Port Austin.

53. Potentilla argentea, L. Silvery Cinquefoil. Roadsides.

54. Potentilla Anserina, L. In an abandoned quarry near the lake at Grindstone City. Also near the lake at Sand Beach. Bayport.

55. Potentilla palustris. Scop. Marsh Five-Finger. In a bog on Sec. 11, Chandler township.

56. Rosa blanda, Aiton, Sweet Wild Rose. Growing in the sand and nearly buried in it at Hat Point.

57. Rosa Carolina, L. Swamp Rose. Swamps. Common.

58. Rosa rubiginosa, L. Sweet brier. Roadside near Port Austin.

59. Pyrus arbutifolia, L. f. var. melanocarpa, Hook. Choke-cherry. Abundant on N. Charity Island.

60. Crataegus punctata, Jacq. Thorn-apple. Hawthorn. Dry fields and woods, Port Austin.

61. Amelanchier Canadensis, Torr. and Gray. Shad-bush. June-berry. Service-berry. Stream banks.

62. Amelanchier Canadensis, Torr. and Gray. Var. rotundifolia, T. & G. Sand dunes.

63. Amelanchier Canadensis, Torr. and Gray. Var. (?) oblongifolia, T. & G. Common on sand dunes.

64. Ribes Cynosbati, L. Prickly Gooseberry. Dry open ground along the lake. Port Austin.

65. Myriophyllum heterophyllum, Michx. Pinnebog River, Port Crescent.

66. Callitriche verna, L. Water Starwort. Dry bed of branch of Pinnebog River, Hume Township.

67. Epilobium spicatum. Lam. Great Willow-herb. Fire weed. Common on all sandy land following fires.

68. Epilobium lineare, Muhl. Bog in Chandler Township.

69. Epilobium coloratum, Muhl. Port Austin.

70. Œnothera biennis. L. Evening Primrose. Common.

71. Circæa lutetiana, L. Common in woods.

72. Circæa alpena, L. Common in low woods.

73. Pimpinella integerrima, Benth and Hook. Dry rocky soil. Port Austin Township.

74. Cicuta maculata, L. Spotted Cowbane. Beaver Poison. Musquash Root. Low grounds, common. Tuberous roots very poisonous.

75. Cicuta bulbifera, L. Bog in Chandler Township.

76. Hydrocotyle Americana, L. Water Pennywort. Moist woods, Port Austin.

77. Aralia racemosa, L. Spikenard. Rich woods, Dwight Township.

78. Aralia hispida, Ventenat. Bristly Sarsaparilla. Wild Elder. Sand dunes. Port Austin.

79. Aralia nudicaulis, L. Wild Sarsaparilla. Rich woods. Meade Township.

80. Aralia trifolia, Decsne & Planch. Groundnut. Dwarf Ginseng.

81. Cornus Canadensis, L. Bunch-berry. Most woods near Port Austin.

82. Cornus circinata, L'Her. Round-leaved Dogwood. Lake shore at Hat Point.

83. Cornus stolonifera, Michx. Red-osier Dogwood. Low ground along streams. Port Austin.

84. Cornus Baileyi, Coulter & Evans. Very common along the lake on sand dunes. Also at Bay Port.

85. Cornus alternifolia, L. f. Near Port Austin, in rich woods.

86. Sambucus Canadensis, L. Common Elder. Roadsides.

87. Sambucus racemosa, L. Red Berried Elder. Dry woods.

88. Viburnum acerifolium, L. Arrow wood. Woods, frequent about Port Austin.

89. Cephalanthus occidentalis, L. Button-bush. Found growing just back of the beach a short distance west of Port Austin, in comparatively dry, light soil. Inland in river bottoms, etc.

90. Galium pilosum, Ait. Sand dunes east of Port Austin.

91. Galium circæzans, Michx. Wild Liquorice. Dry woods.

92. Galium boreale, L. Northern bedstraw. At Point aux Barques.

93. Eupatorium purpureum, L. Joe Pye weed. Trumpet Weed. Along streams and swamps, common.

94. Eupatorium perfoliatum, L. Thoroughwort. Boneset. Low grounds. Common.

95. Eupatorium ageratoides, L. White snake-root. Valley of the Pinnebog River, west of Port Crescent.

96. Liatris cylindracea, Michx. Blazing Star. Sand dunes. West of Port Crescent where it is common.

97. Solidago cæsia. L. Golden-rod. Common.

98. Solidago latifolia, L. Golden-rod. Rich woods in central part of county.

99. Solidago bicolor, L. Var. concolor. Torr. & Gray. Sand dunes.

100. Solidago juncea, Ait. Dry fields and pastures near Port Austin.

101. Solidago serotina, Ait. Low grounds, borders of woods in center of county. Port Austin.

102. Solidago Canadensis, L. Borders of fields, etc., common.

103. Solidago nemoralis, Ait. Sand dunes west of Port Crescent.

104. Aster macrophyllus, L. Wild aster. Dry woods. Common.

105. Aster Novæ-Angliæ, L. A single plant found on north Charity Island. (Common along Saginaw River in Saginaw and Bay counties.)

106. Aster lævis, L. Along the older sand dunes.

107. Aster junceus, Ait. Bog on North Charity Island.

108. Aster puniceus, L. Low grounds throughout the county.

109. Erigeron Canadensis, L. Horse weed. Bitter weed. Waste places and cultivated ground.

110. Erigeron strigosus, Muhl. Daisy Fleabane. Port Austin.

111. Erigeron Philadelphicus, L. Common Fleabane. Common about Port Austin.

112. Ambrosia Artemisiæfolia, L. Ragweed. Roman wormwood. Waste places and roadsides.

113. Xanthium Canadense, Mill. Cocklebur. Clotbur. Along streams and ditches.

114. Rudbeckia hirta, L. Cone-flower. Fields, not common, about Port Austin.

115. Anthemis Cotula, DC. May-weed. Dog-fennel. Roadsides and waste places.

116. Achillea Millefolium, L. Yarrow. Grassy places, common.

117. Chrysanthemum Balsamita, L. Var. tanacetoides. Boiss. Mint Geranium. By the roadside near Port Austin.

118. Tanacetum vulgare, L. Common tansy. Growing in drifting sand near Port Crescent, also by the roadside at other points.

119. Artemisia caudata, Michx. Common on the sand dunes along the lake.

120. Artemisia Absinthium, L. Common wormwood. Roadside near Port Austin.

121. Artemisia Stelleriana, Bess. This plant is well established in the sand of a roadside dune between Port Austin and Port Crescent where it covers a large space. It is also abundant in the barren sand near Huron City, and a large tuft of the plant grows in the sand just back of the storm wave line near the old Carrington Salt Blocks at Port Austin. Prof. Wheeler of the Agricultural College informs the writer that it has not been previously reported as growing wild in the state.

122. Erechtites hieracifolia, Raf. Fireweed. Common in clearings and burned places in the woods.

123. Arctium Lappa, L. Burdock. Waste places, Port Austin.

124. Cnicus lanceolatus, Hoffm. Common thistle. Roadside and pastures.

125. Cnicus Pitcheri, Torr. Shore of the Lake, near Hat Point. Abundant at North Charity Island, not seen back of the crest on the first dune line.

126. Cnicus arvensis, Hoffm. Canada thistle. The northern part of the county is very badly infected with this pest, which seems to have taken possession of many fields and a large number of grain fields seemed to show more thistles than grain. The Canada Thistle Law should be enforced here.

127. Hieracium Canadense, Michx. Hawkweed. Shaded banks about Port Austin.

128. Hieracium venosum, L. Rattle snake weed. Sand dunes from Port Austin westward.

129. Lobelia cardinalis, L. Cardinal Flower. River banks and streams.

130. Campanula rotundifolia, L. Harebell. Rocks and dunes near Port Austin.

131. Campanula aparinoides, Pursh. Marsh Bellflower. Common in grassy swamps.

132. Gaylussacia resinosa, Torr. and Gray. Black Huckleberry. Along woods. Very common on the sand dunes.

133. Vaccinium Pennsylvanicum, Lam. Huckleberry. Low Blueberry. Abundant on the sand dunes and in dry soil generally.

134. Vaccinium vacillans, Solander. Low Blueberry. Sand dunes west of Port Crescent.

135. Vaccinium Corymbosum, L. Swamp or High bush Blueberry. Swamp and marshes about Rush Lake.

136. Vaccinium macrocarpon, Ait. Cranberry. Near Hat Point, and at North Charity Island.

137. Arctostaphylos Uva-ursi, Spreng. Bearberry. On the sand dunes west of Port Crescent.

138. Epigæa repens, L. Trailing Arbutus. Sand dunes under pines near Port Austin.

140. Cassandra calyculata, Dan. Leather-Leaf. Bog in Chandler Township.

141. Chimaphila umbellata, Nutt. Pipsissewa. Prince's Pine. Port Austin near Broken Rocks.

142. Pyrola elliptica, Nutt. Shin-leaf. Pine woods. Port Austin.

143. Trientalis Americana, Pursh. Star-flower. Rich woods near Port Austin.

144. Steironema ciliatum, Raf. Low grounds along streams. S.

145. Samolus Valerandi, L. Var. Americanus. Gray. Water Pimpernel Brook weed. Bank of Pinnebog River. Hume Township.

146. Fraxinus sambucifolia, Lam. Black Ash. Swamps in central part of county.

147. Apocynum androsæmifolium, L. Spreading Dogbane. Near Port Austin.

148. Apocynum cannabinum, L. Indian Hemp. Stream banks near Port Austin

149. Asclepias tuberosa, L. Butter-fly weed. Pleurisy-root. Sand dunes near Port Austin.

150. Asclepias incarnata, L. Swamp milkweed. Swampy margins of streams.

151. Asclepias Cornuti, Decaisne. Common milkweed or silkweed. Roadsides and fields. Grows in bare sand in some places and serves to help keep it from drifting.

152. Menyanthes trifoliata, L. Buckbean. Bog in Chandler Township.

153. Cynoglossum officinale, L. Hound's-tongue. Roadsides near Port Austin.

154. Echinospermum Lappula, Lehm. Waste places. Port Austin.

155. Lithospermum hirtum, Lehm. Puccoon. Sand dunes near Port Austin.

156. Convolvulus sepium, L. Hedge. Bind weed. Wild Morning Glory. Low grounds along the Pinnebog River. Hume Township.

157. Cuscuta Gronovii, Willd. Dodder. Parasite on various plants, valley of the Pinnebog River.

158. Solanum nigrum, L. Common Nightshade. Waste places, Port Austin.

159. Verbascum Thapsus, L. Mullein. Sterile soil, especially where fire has burned the other vegetation off within a few years.

160. Linaria Canadensis, Dumont. Sand dunes west of Port Crescent.

161. Linaria vulgaris, Mill. Butter and Eggs. Roadside, Bay Port.

162. Chelone glabra, L. Snake head. Banks of streams.

163. Mimulus ringens, L. Monkey-flower. Damp, open ground about Port Austin.

164. Veronica Americana, Schweinitz. American Brooklime. Brooks near Port Austin.

165. Gerardia pedicularia, L. Dry, sandy woods. North Charity Island.

166. Gerardia quercifolia, Pursh, Smooth False Foxglove. Dry sandy woods, North Charity Island.

167. Gerardia purpurea, L. Var. paupercula, Gray. Purple Gerardia. Very common on the shore near the hotel, Bayport. Also at Charity Island.

168. Utricularia intermedia, Hayne. Holes in the bog, Chandler Township.

169. Utricularia cornuta, Michx. Bladderwort. In shallow pool left by the retreat of the lake, on the beach just east of Port Austin. A small flowered stunted form of the species, common at Bayport on the flats along the Bay shore.

170. Verbena urticæfolia, L. White Vervain. Port Austin.

171. Verbena hastata, L. Blue Vervain. Low grounds, common.

172. Mentha piperita, L. Peppermint. Roadside near Port Austin.

173. Mentha Canadensis, L. Wild Mint. Low grounds and along streams.

174. Calamintha clinopodium, Benth. Basil. Dry banks and dunes about Port Austin.

175. Monarda fistulosa, L. Wild Bergamot. Sandy fields near the dunes. Port Austin.

176. Nepeta Cataria, L. Catnip. Waste places. Port Austin.

177. Scutellaria lateriflora, L. Low grounds. Pinnebog River, etc.

178. Scutellaria galericulata, L. Skullcap. Bog in Chandler Township.

179. Marrubium vulgare, L. Horehound. Roadside near Port Austin.

180. Leonurus Cardiaca, L. Motherwort. Waste places. Port Austin.

181. Brunella vulgaris, L. Self-heal. Woods and thickets.

182. Amarantus albus, L. Tumble weed. Growing in the sand at Port Austin and Port Crescent.

183. Chenopodium Botrys, L. Jerusalem Oak. Feather. Geranium. Ambrosia. Growing abundantly in the dune sand at Port Austin and about the old salt block at Port Crescent.

184. Chenopodium album, L. Pigweed. Common in waste places and cultivated ground.

185. Chenopodium capitatum, Watson. Strawberry Blite. Occasional in woods.

186. Rumex crispus, L. Curled Dock. Yellow Dock. Too common.

187. Rumex obtusifolius, L. Bitter Dock. Common in waste places.

188. Rumex Acetosella, L. Field or sheep sorrel. Common.

189. Polygonum aviculare, L. Knotweet. Common.

190. Polygonum erectum, L. Common along roadsides.

191. Polygonum orientale, L. Prince's Feather. Port Austin.

192. Polygonum Persicaria, L. Lady's Thumb. Gull Island, Lake Huron. Also in wet places.

193. Polygonum cilinode, Michx. Bindweed. Waste heaps about the quarries at Grindstone City. Rocky places west of Port Austin.

194. Polygonella articulata, Meisn. Abundant on the outer row of sand dunes.

195. Saururus cernuus, L. Lizard's-tail. Pinnebog River. Hume Township.

196. Shepherdia Canadensis, Nutt. Point Aux Barques on sandstone rocks overhanging the lake. Also on sand dunes west of Port Crescent.

197. Comandra umbellata, Nutt. Dry woods near Port Austin.

198. Euphorbia Cyparissias, L. At Bayport, where it covers considerable area. Also at Port Austin and Huron City in sand.

199. Ulmus Americana, L. White, or American Elm. Low grounds, common.

200. Humulus Lupulus, L. Common Hpp. Near Port Austin.

201. Betula lutea, Michx. f. Yellow Birch. Common in low woods.

202. Betula papyrifera, Marshall. Paper or Canoe Birch. White Birch. Common

203. Alnus incana, Willd. Speckled or Hoary Alder. Borders of streams.

204. Quercus alba, L. White Oak. Sand dunes at Port Austin.

205. Quercus rubra L. Red Oak. Common on the sand dunes, where it is sometimes a large tree, but not usually. Evidently the large specimens have been cut for timber.

206. Quercus coccinea, Wang. Scarlet Oak. The most abundant species of oak in the dunes.

207. Fagus ferruginea, Ait. Beech. Common throughout the county on heavier soils.

Salix. Several species of Willows are common but were not found in favorable condition for study.

208. Populus alba, L. White Poplar. Port Austin.

209. Populus tremuloides, Michx. American Aspen. Quaking asp. Common in the east half of the county.

210. Populus grandidentata. Michx. Large-toothed Aspen. Common.

211. Populus balsamifera, L. Balsam Poplar. Perhaps the most abundant species in the districts most affected by the great fires.

212. Populus monilifera, Ait. Cottonwood. Occasional.

213. Vallisneria spiralis, Tape Grass. Eel Grass. Mouths of Pinnebog and Pigeon Rivers.

214. Calopogon pulchellus, R. Br. Marsh at Rush Lake.

215. Iris versicolor, L. Blue Flag. Low grounds. Common.

216. Smilax hispida, Muhl. Port Austin.

217. Smilacina stellata, Desf. False Solomon's Seal. Common on sand dunes west of Port Crescent.

218. Juncus effusus, L. Soft Rush. Common in low ground.

219. Juncus Balticus, Dethard. Var. littoralis, Engelm. Very common in the beach sand at Port Austin where it forms large masses in the sand for several hundred feet back from the shore, especially up the creek valley.

220. Juncus bufonius, L. Forming extensive tracts on the marshy area left by the fall of the waters of the lake during the past few years.

221. Juncus alpinus, Villars, Var. insignis, Fries. Abundant in the creek valley at Port Austin, also not uncommon along the Lake shore.

222. Juncus nodosus, L. Common with the last species.

223. Juncus Canadensis, J. Gay. Same habitat as the last species.

224. Juncus Canadensis, J. Gay. Var. coarctatus Engelm. Port Austin.

225. Juncus Canadensis, J. Gay. Var. brachycephalus, Engelm. Port Austin.

226. Luzula vernalis, DC. Wood-rush. Common in moist woods.

227. Typha latifolia, L. Cat-tail Flag. Rush Lake. Marsh in Chandler Township.

228. Sparganium eurycarpum, Engelm. Burr-reed. Pinnebog River.

229. Alisma Plantago, L. Water Plantain. Common in streams.

230. Sagittaria variabilis, Engelm. Stream borders.

231. Triglochin palustre, L. Arrow-Grass. Marshy border of Lake Huron. Port Austin.

232. Potamogeton natans, L. Pondweed. Terrestrial forms of this species noted on shore of partly dried up lake in Chandler Township and in bottom of dried up pond on Charity Island.

233. Potamogeton heterophyllus, Schreb. Small form in shallow pools above low water mark, on beach east of Port Huron.

234. Potamogeton heterophyllus, Schreb. Forma longipedunculatus (Merat) Morong. This form was collected in water nearly four feet deep off the beach at Point of Pines Hotel, Port Austin. The root stocks of the plants grow in crevices in the rocks, and the plants thrive in spite of the violent surf which frequently breaks on this shore.

235. Potamogeton pauciflorus, Pursh. Var. Niagarensis, Gray. Pinnebog River.

236. Potamogeton pectinatus, L. Pigeon River, Caseville.

237. Potamogeton marinus, L. Shallow water, less than one foot deep on beach between Port Austin and Port Crescent. Also at North Charity Island in water six inches deep, abundant at both localities.

238. Naias flexilis. Rostk and Schmidt. Willow River, Huron Township.

239. Cyperus diandrus, Torr. Var. castaneus, Torr. Very common along the lake shore, and along margins of streams.

240. Cyperus Houghtonii, Torr. Abundant on the sand dunes west of Port Crescent, where it grows in the purest sand, often in the wagon tracks across the dunes.

241. Cyperus strigosus, L. Common in marshy places along the lake at Port Austin.

242. Dulichium spathaceum, Pers. Rush Lake.

243. Eleocharis ovata, R. Br. Common along the shore of the lake.

244. Eleocharis olivacea, Torr. Lake shore.

245. Eleocharis palustris, R. Br. Var. glaucescens, Gray. Common in wet places.

246. Eleocharis acicularis, R. Br. Spike-rush. Very abundant along the lake shore.

247. Eleocharis pauciflora, Link. Forming large masses on the marshy belt left by the retreat of the lake near Port Austin. Bayport.

248. Scirpus pungens, Vahl. Growing in moist sand for several hundred feet away from water at Port Austin Harbor. Bayport.

249. Scirpus lacustris, L. Common, especially at Rush Lake, where it forms large masses.

250. Scirpus atrovirens, Muhl. Damp soil, common. Very abundant near the R. R. station, Port Austin. Bayport.

251. Cladium mariscoides, Torr. Twig-rush. Marsh about pond on North Charity Island.

252. Carex lupulina, Muhl. Common along ditches, etc.

253. Carex filiformis, L. Bog in Chandler Township.

254. Carex flava, L. Var. viridula, Bailey. Abundant at Bayport and Charity Islands in the marshy tract left by retreat of lake. Less common at Port Austin. At North Charity Island, some plants were 18 inches high.

255. Carex riparia, W. Curtis. River banks.

256. Carex eburnea, Boott. Crevices in sandstone bluff overhanging the lake.

257. Carex Pennsylvania, Lam. Common throughout.

258. Carex communis, Bailey. Port Austin Township, near Grindstone City.

259. Carex stipata, Muhl. Common in low places.

260. Carex vulpinoidea, Michx. Meadows, common.

261. Carex Muhlenbergii, Schb. Dry soil on the bluffs. Point aux Barques.

262. Carex tribuloides, Wahl. Common in low grounds.

263. Carex tribuloides, Wahl. var. cristata. Bailey. Swales, common.

265. Spartina cynosuroides, Willd. Marsh or cord grass. Sand dunes.

266. Panicum sanguinale, L. Crab or Finger Grass. At Port Crescent in drifting sand where it was getting a foothold and may help hold the sand in place.

267. Panicum virgatum, L. Charity Islands on sand soil.

268. Panicum capillare, L. Old Witch-Grass. Common.

269. Panicum dichotomum, L. Sand dunes west of Port Crescent.

270. Setaria viridis, Beauv. Green Foxtail. In loose sand at Port Crescent, with Panicum sanguinale.

271. Zizania aquatica, L. Indian Rice. Water oats. Wild rice. Marshy places along the lake shore, usually small in such locations. Off Bayport, however, it grows in shallow water to the height of several feet, covering large tracts, and undoubtedly acting as an important factor in the filling up of the portions of the Bay in which it grows, by decreasing wave and current motion of the water, hence hastening deposit.

272. Andropogon furcatus, Muhl. North Charity Island.

273. Oryzopsis asperifolia, Michx. Sides of older dunes about Port Austin.

274. Oryzopsis Canadensis, Torr. Sand dunes, where it is common.

275. Phleum pratense, L. Timothy. Herd's Grass, common. Extensive crops of this grass may be raised in the swampy tracts south and east of Badaxe when they are cleared and drained.

276. Agrostis scabra, Willd. Hair-grass. Dry pastures in Huron Township.

277. Calamagrostis longifolia, Hook. Sand dunes about Port Austin.

278. Ammophila Arundinacea, Host. Sand dunes nearest lake. Common.

279. Deschampsia flexuosa, Trin. Common Hair-Grass. Abundant in the dunes of Port Austin.

280. Phragmites Communis, Trin. Reed. Border of dry pond in Charity Island.

281. Danthonia spicata, Beauv. Wild Oat-Grass. Sand dunes, common.

282. Koeleria cristata, Pers. Slopes of the older sand dunes.

283. Eragrostis reptans, Nees. Along the lake shore and borders of streams.

284. Poa compressa, L. Wire-Grass. Blue-Grass. The top of the bluffs at Point aux Barques.

285. Poa pratensis, L. June Grass. With the last and common everywhere.

284. Festuca tenella, Willd. Common on sand dunes and on the dry soil at Broken Rocks, Port Austin.

287. Festuca ovina, L. Var. pseudovina, Hack. Broken Rocks near Port Austin. ?

288. Agropyrum dasystachyum, Vasey. Common on the sand dunes.

289. Elymus Virginicus, L. Wild Rye. Valley of Pinnebog River, Hume Township.

290. Elymus Canadensis, L. Growing on the sand dunes nearest the lake at Port Austin. Abundant.

291. Asprella Hystrix, Willd. Bottle Brush Grass. Woods near Port Austin.

292. Pinus Strobus, L. White Pine. Formerly very abundant throughout a large portion of the county, mostly confined in the dunes near the lake.

293. Pinus Banksiana, Lambert. Jack Pine. Scrub Pine. Common on the sand dunes. Not seen east of Broken Rocks, Port Austin. West of Port Crescent it is common even on the crest of the dune line nearest the lake.

294. Pinus resinosa, Ait. Norway Pine. Red Pine. Common on the sand dunes.

295. Picea nigra, Link. Black Spruce. In low woods west of Filion.

296. Larix Americana, Michx. Black Larch. Tamarack. Swamps in the southern part of the county.

297. Tsuga Canadensis, Carriere. Hemlock. Banks of Willow River in Huron Township.

298. Abies balsamea, Miller. Balsam fir. Balm-of-Gilead Fir. A few specimens about a boggy place on the dunes east of Port Crescent. Swamp just west of Port Austin.

299. Thuya occidentalis, L. Arbor Vitæ. White Cedar. Wet places near Port Crescent.

300. Equisetum arvense, L. Horsetail. Low grounds, common.

301. Equisetum hyemale, L. Scouring-Rush. Shave-Grass. Sand dunes east of Port Austin.

302. Equisetum variegatum, Schleicher. What seems to be this species was not uncommon in the sand near Port Austin.

303. Polypodium vulgare, L. Under overhanging rocks along the Lake shore, Point aux Barques, etc.

304. Adiantum pedatum, L. Maidenhair fern. Rich woods.

305. Pteris aquilina, L. Common brake. Very common in northern part of county.

306. Phegopteris polypodioides, Fée. Under overhanging rocks of old shore cliff, east of Point aux Barques.

307. Phegopteris Dryopteris, Fée. With the last species.

308. Onoclea sensibilis, L. Sensitive fern. Common in low grounds.

309. Osmunda regalis, L. Flowering Fern. Deep woods in the middle of the county.

310. Woodsia obtusa, Torr. Growing abundantly in crevices in the overhanging rocks on the Lake shore near Port Austin.

311. Lycopodium complanatum, L. Var. Chamæcyparissus, D. C. Eaton. Common on the sand dunes, east of Port Crescent.

312. Selaginella apus, Spreng. In old quarry at Grindstone City.

A visit of a day's duration to Bayport in July, 1898, indicates that the flora of that part of the county is especially interesting to botanists, as a number of species of plants were found there which have not before been found so far north in Michigan and some reach their most northern recorded limit here.

14a. *Hypericum Kalmianum, L. St. John's-wort. Marshy land south of Bayport.

30a. Medicago sativa, L. Alfalfa, Lucerne. Along the line of the sewer from the Bayport Hotel to the Bay.

66a. Lythrum alatum, Pursh. Purple Loose-strife. Marshy borders of ditches, between Sebewaing and Bayport.

96a. Liatris spicata, Wild. Blazing-star. Marshes north of Sebewaing.

103a. Solidago Ohioensis, Riddell. Golden-rod. Marsh near Bayport.

111a. Silphium terebinthinaceum, L. Prairie Dock. Along the S. T. & H. R. R. nearly as far north as Bayport.

121a. Cacalia tuberosa, Nutt. Tuberous Indian Plantain. North of Sebewaing nearly to Bayport, in rich soil.

128a. Lactuca scariola, L. Prickly lettuce. A bad weed common about the railroad stations.

129a. Lobelia Kalmii, L. Wet flats along the shore of the Bay at Bayport.

144a. Steironema longifolium, Gray. Marshes south of Bayport.

181a. Plantago Patagonica, Jacq. Var. aristata, Gray. Bristly Plantain. Grounds of the Bayport Hotel under trees, sandy soil.

207a. Salix amygdaloides, Anders. Bayport.

213a. Spiranthes cernua, Richard. What seems to be this species was collected by Dr. Lane in the neighborhood of Bayport.

*These numbers refer to the place which these plants would occupy if arranged in the foregoing list.

CHAPTER X. THE FOSSILS.

§ 1. Introduction.

When we attempt to study and name the forms of life which have left their traces in the rocks of Huron county we find ourselves in much difficulty. The earlier papers on the subject by Winchell, Strong and Stevens, were published without illustrations. All the illustrations that Douglas Houghton prepared seem to have disappeared. At the Ann Arbor Museum and Grand Rapids High Schools, however, are numerous forms labelled, so that after diligent study by one who has access to the complete literature of other states (especially whenever Winchell's unpublished drawings become accessible), we shall know better just what forms have been named by the gentlemen above, and how far they are equivalent to forms described in other states. In the meantime geologists in other states have worked perforce without very much regard to what had been done in Michigan, though Herrick and others have occasionally referred to Winchell's types. The material is in large part so imperfect that Winchell has in a number of cases referred a form now to one genus and now under another, retaining the same specific name. Rominger, too, collected extensively in the county, but his identifications are generally not specific and by no means always harmonize with those of previous authors. In consequence the following cases of difficulty arise:

We may be almost certain that a form has been given a certain specific name by a previous author, but doubt if his reference of it to a certain genus is correct; or we may not be certain whether we have the exact form described by a certain author. Or we may find the same form referred to by different authors under different names. In some cases we know that this is so, as when Hall uses Winchell's figures of *Centronella Julia* to illustrate *Cryptonella*. The same form is now known as *Romingerina*.

The snarl thus involved can not be straightened out at once. But we can at least take out some kinks, and make it easier for the next one, and at the same time give lists which show what names have been applied to the fossils of the county.

We treat the fossils of the Marshall and underlying shales together, for even if we did not wish to imply thereby very much, as to the controverted question of their relation to the line between Devonian and Carboniferous, since the literature is the same, and we shall have occasion to compare the forms, it seems better to treat them thus.

We have illustrated part of the Marshall fauna in Plates X and XI, but have not tried to do so for the faunas of the Bayport, i. e., Maxville limestone, reserving that for a Kent county report when the collections of the Kent Scientific institute shall be accessible, and shall have been properly worked up.

It is impossible, too, to do complete justice to the Marshall fossils until Winchell's collection is also accessible to the investigator, which we trust will be soon, now that it is acquired by the Francis Hood Museum of Alma College. But I am particularly indebted to Mr. W. F. Cooper who is familiar with Mr. Herrick's parallel work in Ohio for his assistance in that section. Most of the forms illustrated in Plates X and XI are not Marshall, but come from the Point aux Barques lighthouse. I hope to illustrate the Marshall more fully later from Winchell's own drawings but most of his specimens came from the southern part of the state.

§ 2. Recent shells (of the marl), by Bryant Walker and A. C. Lane.

It has been suggested by certain recent observers* that the former extension of the Great Lakes so well marked in raised beaches around the lower peninsula of Michigan, were really connected with the ocean and their deposits of marine origin, and for this and other reasons, during the progress of the investigations of the Geological Survey, in Huron county, last summer, some attempt was made by Prof. Davis and Mr. Lane to gather shells from recent deposits, where they would be likely to throw light upon the subject. These shells have been referred to Mr. Bryant Walker and the Pisidia to Dr. V. Sterki to whom all that is valuable of this paper should be attributed. All that Mr. Lane adds is something concerning the localities.

* Spencer, J. W., Science, 1888, Jan. 27, p. 49, Pop. Sci. Monthly, 1896. Bela Hubbard, back in 1840, correctly described them as fresh water deposits.

Locality (1).—Near Badaxe, about one-fourth mile N. of the southeast corner of Sec. 24, T. 16, R. 12; altitude about 180 feet above the present lake level, or say 760 feet A. T. Here the E.—W. drain exposes a section showing an alternation of above a marshy deposit, then a shell marl, then another marshy deposit, then a second bed of shell marl. Mr. Lane's attention was called to the alternation by Dr. Jas. Henderson. At the time it was visited, the section was exposed by a ditch which was so filled with water that a careful separation could not be made of the two marls, but without doubt, the forms were very largely derived from the lower marl. It seems geologically very likely that the lower marl is associated in this region with, and nearly contemporaneous with, the Forest Beach of Lake Warren.* A collection was made from a marl at a similar altitude and in association with marshes also behind the Forest Beach on Sec. 6, Sherman, T. 15 N., R. 16 E., in 1897. The fauna was similar and *Pisidium contortum* occurred again.

*See F. B. Taylor, Bull. Geol. Society of America, Vol. VIII, p. 49.

Locality (2).—Close to the Stone Wall also referred to by Taylor (loc. cit., page 44), in the swamp in which the Stone Wall is connected and at a similar elevation. This is in the southeast corner of Sec. 32, T. 14 N., R. 11 E. This, too, is very possibly to be correlated with the time of the Forest Beach and Lake Warren,—according to Taylor this marsh lies in the Cumber spillway, a channel by which the waters on the two sides of the thumb were connected when the ice front was standing near Verona.

This locality is more fully described in Part III of this volume.

Locality (3).—Sand which was exposed in burning off the bog near the corner of Secs. 26 and 27, T. 16 N., R. 9 E. Fairhaven township, Huron county, Michigan. These sands lie at an elevation of a little above 20 feet (605 ft. A. T.). They are to be connected with the Algonquin Beach, according to Taylor. They certainly are connected with the old lake shore directly in a way that the two marl deposits just mentioned are not.

Locality (4).—On the north side of Sec. 34, T. 16 N., E. 9 E., about 1/4 mile E. of the N. W. quarter where the section line road crosses the dunes. They are connected with the same Algonquin lake level as the previous locality, though somewhat higher, and are evidently fragments thrown up on the beach directly connected with the dune deposits.

Finally collections were also made of recent forms for comparison.

Locality (5).—Living forms collected by C. A. Davis at Port Austin.

Locality (6).—Living forms collected by Mrs. A. C. Lane, in flats laid bare by the recent fall of the waters in front of Bayport during the last eight years. It will be seen from the lists that with two exceptions, all the species found are identical with forms now existing in the same region. Such variations as now exist are no more than can be attributed to local peculiarities of environment. The fauna of the older marls as a whole is undoubtedly a northern one, and indicates, though not necessarily conclusively, a colder climate than exists in that region today. This inference is based on the uniformly small size of the same species, i. e., *Valvata tricarinata*, *Planorbis deflectus*, *Planorbis bicarinatus* and the Campeloma, also the peculiar sculpturing of the *Planorbis bicarinatus*.

The single example of Campeloma is a very interesting one, though it is unfortunately very imperfect. It is apparently mature, and is remarkable for its small size and cylindrical shape. It also resembles the northern recent form known as *Campeloma milesii* Lea, but is smaller and more cylindrical. If the form of the living species is the result of its northern situation, it would perhaps be a fair inference that severer climatic conditions had so to speak intensified the form. However, while *C. milesii* is today a northern form, there are other species of the same genus ranging from the same territory, as well as further north, which do not show the same peculiarity. Then there is a little *Limnæa* from Badaxe, locality (1), which is also interesting. It resembles the species from the Moose River, in the Hudson Bay territory, described by Lea as *L. artica*, but differs in its compressed shape and in being decidedly umbilicate.

In regard to the *Pisidia* in particular, Dr. V. Sterki, who examined the material, says that the Badaxe specimens are of especial interest and correspond with those from the marl in Aroostook county, Maine. There is in both *Pisidium contortum* Pme., a form which has been referred to or near *Pisidium milium* Held, from Europe, and certainly is nearly related, but the species is very variable. The extreme forms might be regarded as quite distinct species, but for intermediate forms. *Pisidium contortum* is known only as fossil, but may yet be found living further north.* *P. ventricosum* Pme. so common in the Maine marl was not represented in the Michigan material. In the Fairhaven material location (3) or (4) were a few broken fossils, one of them to be identified as *Pisidium contortum*, the balance too far gone.

It is obvious from the comparison of these lists appended and observations made upon them that so far the shell collections point, not to marine conditions, but to fresh water conditions something similar to those present, but to a more northern climate, which is in every way agreeable to the other geological indications, that their erstwhile denizens dwelt in lakes left upon the retreat of the ice, the shells from localities (1) and (2) being probably more nearly contemporaneous with the ice front and with the mastodon.†

In the list, the names of the genus, species and describer are first given, in order, grouped by genera, and then in the seven following columns, their occurrence in Walker's list of shells of the Saginaw valley‡ and in the six localities above mentioned. An X indicates the presence of form, XX its abundance, a number added refers to foot note.

? indicates that the specimen is too imperfect for certain identification.

Genus.	Species.	Author.	Walker's list.	Loc. 6.	5.	4.	3.	2.	1.
Circinaria	*concava*	Say	x						
Zonitoides	*nitidus*	Mull	x						
"	*arboreus*	Say	x					x	
"	*minusculus*	Alder	x						
Vitrea	*hammonis*	Ström	x						
"	*indentatus*	Binn	x						
Conulus	*fulvus*	Dr.	x						
Gastrodonta	*multidentata*	Say	x						
Pyramidula	*alternata*	Say	x						
"	*perspectiva*	Say	x						
"	*striatella*	Anth	x						
Helicodiscus	*lineatus*	Say	x						
Punctum	*pygmaeum*	Drap	x						
Polygra	*multilineata*	Say	x						
"	*thyroides*	Say	x						
"	*albolabris*	Say	x						
"	*albolabris dentata*	Tryon	x						
"	*exoleta*	Binn	x						
"	*sayii*	Binn	x						
"	*monodon fraterna*	Say	x						
"	*leaii*	Ward	x						
"	*tridentata*	Say	x						
"	*palliata*	Say	x						
"	*virgata*	DaCosta	x						
Vallonia	*pulchella*	Mull	x						
Strobilops	*labyrinthica*	Say	x						
Bifidaria	*corticaria*	Say	x						
Bifidaria	*armifera*	Say	x						
"	*contracta*	Say	x						
"	*pentodon*	Say	x						
"	*curvidens*	Gld	x						
Vertigo	*ovata*	Say	x						
"	*gouldii*	Binn	x						
"	*ventricosa elatior*	Sterki	x						
Cochlicopa	*lubrica*	Mull	x						
Succinea	*ovalis*	Say	x						
"	*avara*	Say	x						
"	*retusa*	Lea	x		x				
"	*peoriensis*	Wolf	x						
"	*sp*		x						
"	*sp*		x						
Carychium	*exiguum*	Say	x						
Limnæa	*stagnalis*	L.	x		x				
"	*catascopium*	Say	x	x	x				
"	*reflexa*	Say	x		x				
"	*reflexa scalaris*	Walker	x						
"	*palustris*	Mull	x		x				
"	n. sp								x(1)
"	*cubensis*	Pfr	x						
"	*desidiosa*	Say			x			xx	x
"	*emarginata*	Say			x				
Physa	*ancillaria*	Say	x		x			x	
"	*sayii*	Tappan	x	x					
"	*gyrina*	Say			x			x	
"	" *var. hildrethiana*	Lea	x						
Aplexa	*hypnorum*	L.	x						
Planorbis	*trivolvis*	Say	x						
"	*multivolvis*	Case	x		x				
"	*bicarinatus*	Say					x	xx	xx(2)
"	*truncatus*	Miles		x	x				
"	*deflectus*	Say					x	xx	xx
"	*campanulatus*	Say	x				x	x	xx
"	*albus*	Mull	x						
"	*parvus*	Say	x		x				
"	*exacutus*	Say	x						
Segmentina	*armigera*	Say	x		x				
Ancylus	*fuscus*	Ad							
"	*sp*								?
"	*parallelus*	Hald	x						
Lyogyrus	*pupoidea?*	Gld	x						
Valvata	*tricarinata*	Say						xx(4)	xx(3)
Campeloma	*milesii*	Lea		x					
"						?(5)			
"	*decisa*	Say	x						
Amnicola	*sp.*				x				
"	*porata*	Lea	x						
"	*limosa*	Say					x	x	
Bythinella	*obtusa*	Lea							
"	*nickliniana*	Lea	x		x				
Goniobasis	*livescens*	Mke	x	x	x	x	x		
"	*semicarinata*	Say	x						
"	*depygis*	Say	x						
"	*milesii*	Lea	x						
Unio	*alatus*	Say	x						
"	*asperrimus*	Lea	x						
"	*cornutus*	Bar	x						
"	*ellipsis*	Lea	x						
"	*coccineus*	Hild			x				
"	*gibbosus*	Bar	x				?		
"	*gracilis*	Bar	x						
"	*ligamentinus*	Lam	x						
"	*luteolus*	Lam	x	x	x				
"	*nasutus*	Say	x						
"	*novi-eboraci*	Lea	x						
"	*phaseolus*	Hild	x						
"	*rectus*	Lam	x						
"	*rubiginosus*	Lea	x						
"	*schoolcraftii*	Lea	x						
"	*ventricosus*	Bar	x		x				
Margaritina	*deltoidea*	Lea	x						
Anodonta	*edentula*	Say			x				
"	*fragilis*	Lam			x				
"	*benedictii*	Lea	x						
"	*footiana*	Lea	x		x				
"	*imbecilis*	Say	x						
Sphaerium	*striatinum*	Lam	x	x			x		
"	*simile*	Say			x				x
"	*securis*	Prime						x	x
"	*rhomboideum*	Say	x						
"	*occidentale*	Pme	x		x				
"	*partumeium*	Say	x						
"	*truncatum*	Lind	x						
Pisidium	*virginicum*	Lam	x						
"	*abditum*	Hald	x					x	x
"	*compressum*	Pme	x					x	x
"	*variable*	Pme	x					x	x
"	*contortum*	Pme				x	?x	x	x
"	"	Var ?						x (6)	x (6)
"	*rotundatum*	Pme						x	x
"	*scutellatum*	Sterki ?							x
"									

*It has recently been found living in northern Maine.

†See articles by B. Walker in the Nautilus March, 1898, Vol. XI, p. 121, and Sept., 1899, Vol. XIII, p. 55.

‡Nautilus, 1894, p. 125.

(1) Peculiar, two specimens, lacking the spire, whorls strongly shouldered, beneath which is a well marked constriction, which modifies the form of the aperture, lip sinuous, drawn back and somewhat expanded posteriorly, body whorl almost cylindrical.

(2) Spiral lines much more developed than is usual in living specimens. Many of the adult specimens are considerably corrugated transversely toward the aperture and after the period of the first growth. According to R. E. C. Stearns (Proc. Phila. Acad. Nat. Science, 1881, p. 104), such a tendency is evidence of considerable changes in temperature or environment.

(3) Exhibiting all stages from the unicarinate to the tricarinate form,—none ecarinate.

(4) Mostly bicarinate.

(5) See above, p. 249.

(6) See above, p. 249.

§ 3. Fossils of the Marshall and Coldwater by A. C. Lane and W. F. Cooper.

A list is given in the Proceedings of the American Philosophical Society (1870), Vol. XII, p. 389 including all the fossils which Winchell has described from this group. We can divide the 260 feet of the Lower Marshall (the Upper Marshall or Napoleon is so far as yet known unfossiliferous in the county) in two to three divisions, two of which we can also trace in the previous writers. The shales and intercalated sandstones below we can also divide into three zones. Having regard indeed only to our own collections we might subdivide some of these divisions, but as the subdivision grows finer the danger of placing forms in the wrong division increases with no compensating advantage, so that the division given below will suffice. At the same time in discussing our collections, the exact place in the column will be noted as far as possible.

The divisions we make are then:

(1) Lowest, the Rock Falls, Cuyahoga series, 176-553, especially 460 feet below the bottom of the Lower Marshall, =541 feet above the top of the Berea grit, with *Chonetes scitulus*, Plate X, Figs. 1 and 2.

(2) The Lighthouse Point series 100-176, especially 160-176 feet below the bottom of the Marshall as defined, very fossiliferous, with *Syringothyris pharovicina* (Plate X, Figs. 5-7) and numerous spirifers, and a fair sized *Proetus missouriensis* and abundant Schizodus forms (Plate XI, Figs. 7, 9, 14, 15), generally larger than corresponding forms in higher horizons, which are, however, faunally closely allied.

(3) The Huron City series. 0—100 feet below the Lower Marshall, especially 84 feet below the bottom of the Marshall, Rhynchonelloids and Productus more abundant and smaller than in the Lower Marshall.

(4) The Point aux Barques series 85-260 feet below top of Lower Marshall, including the gritstones themselves (235-260), with fish remains and *G. Oweni*, zone of *Romingerina julia* above, at 220 feet, and all the strata up to the top of the Port Austin sandstone.

(5) The Solen series (65-85 feet below top), characterized by the abundance of Solen like forms and *G. marshallensis* including the richly fossiliferous zone of Hardwood Point, with *Prothyris meeki* (Plate XI, Fig. 10).

The upper beds, as exposed on the Port Austin and Port Crescent road,—thin-bedded flags, especially rich in small aviculoid forms, Leiopteria and Sanguinolites, Figs. 2, 11, 12, 13, Plate XI, this last zone not having been before observed in the county—are not an essentially new series.

(1). **The Rock Falls series** (Cuyahoga).

Like the corresponding Cuyahoga shales of Ohio, the blue shales are very poor in fossils, except in thin sandy seams and nodules of carbonate of iron, but Dr. Gordon discovered *Chonetes scitulus* a small delicate species, (? Chonetes of Rominger, Sp. 19147), and *Conularia gracilis*.* Fucoidal remains, as suggested by Rominger (Caudagalli) in our specimen more likely worm-produced marks (Sp. 19148-19150), together with the Chonetes and Goniatites noticed by Rominger (III, 76) are not unlike the fauna of the Bedford and Cuyahoga (cf. Ohio VII, p. 32, 507) shale. Mr. G. H. Girty collected in the summer of 1897 with me also *Productus lævicosta*, and two other species, one probably *Productus blairi*, *Spirifer centronota,* Syringothyris, lamellibranchs, and heads as well as stems of crinoids. Cooper identified *P. Shumardianus*, and *P. newberryi* var. *annosus*, and *Streblopteria media*, *Phæthonides spinosus*. The other localities from from Port Hope down have not added to the list of species, but these suffice to identify it with the Cuyahoga of Central Ohio. The fauna is somewhat Devonian in aspect.

*Ohio VII, Pl. XIX. Sp. 19146.

(2). **Lighthouse zone.**

Most of the fossils of this section come from the conglomerate and from one belt of sandstone about 3 inches thick.* The fauna is exceedingly rich. Not less than forty species and all the principal groups are represented. A characteristic feature of this fauna to be noted, is the comparatively large size of the forms. This is to be noted, not only as a whole, but in comparing any particular form with its nearest ally in the formations above. The minute *Romingerina julia* of series (4) is represented by larger terebratuloid forms, perhaps the form described by Winchell as *Merista Houghtoni*, compare Plate X, Fig. 13 (for in default of knowledge of the internal structure, these forms may be wrongly attributed to different genera). The Proeti have glabellas 15 mm. or so long (Plate XI, Fig. 14), while the next trilobite that we notice (Sp. 19094) is almost microscopic. The lamellibranchs and brachiopods are also large, often attaining a length of 20 to 40 mm, and the rhynchonellas attain about twice the size of those higher up in the series (Plate X, Fig. 8, 9, 10).

*See pp. 25, 87.

SPIRIFER SUBATTENUATUS, Hall? (Proc. Acad. Nat. Sci., Phila., 1862, p. 405).

Winchell says merely that the form agrees with Hall's descriptions and in the Proceedings of the American Philosophical Society he speaks of it as a doubtful identification. At least four, probably more of the Spirifer family are found by us, some with, some without striations in the sinus, sometimes fasciculated. Compare Sp. 19049, 19045. This is a small Spirifer, but our forms appear rather too elongate, more of the mucronatus type.

SPIRIFER MEDIALIS, Hall? The specimens, here and there, through the whole series 19044 to 19089 show another type of flatter, and not very large spirifer. Winchell's identification is almost certainly erroneous.

SPIRIFER HURONENSIS, Win. is described as follows, P. A. N. S., Phil., 1862, p. 407. This we have figured, Plate X, Fig. 3. Compare *S. deltoideus*.

"*Spirifera Huronensis*, n. Sp. Shell of medium size, transversely semi-elliptic, with acuminate hinge-extremities; entire hinge-length nearly three times the length of the shell; anterior and antero-lateral borders regularly curved. Ventral valve ventricose, especially towards the beak, which is erect over a high triangular area, triangularly foraminated at the apex; sinus beginning near the beak, not well defined, round at its margins and bottom; entire surface covered with about forty rounded ribs, of which the lateral half on each side terminate upon the cardinal border, while about four of the same size as their neighbors, occupy the sinus. Dental plates standing at an angle of 58°. Dorsal valve equally tumid with the ventral; beak incurved over a narrow area; mesial fold indistinct, with three or four ribs; occlusor and pedicle scars lanceolate, deep. Surface of shell with one or two squamous incremental lines.

"Length of shell, in inches, .49 (100); length of hinge line 1.3 (265); convexity of ventral valve .25 (50).

"Locality. Lighthouse Pt. aux Barques, in a hard, gray, pyritous, coarse, often conglomeritic bed of sandstone two feet thick, intercalated in the argillaceous slates of the Huron group."

Specimen 18263 and 19048, seem to show this type of spirifer well. It will be noted that there is nothing in the description of this and the next species to prevent its being a Syringothyris, which it may be.

SYRINGOTHYRIS PHAROVICINA, Win. described, Proc. Acad. Nat. Sci. Phil., 1862, p. 406, as follows, under the name *Spirifer pharovicina*:

"Shell large and ventricose. Ventral valve with a gentle sinuation which extends to the beak; dental plates moderately long, forming an angle of 80°; area very elevated, with a narrow triangular fissure reaching to the apex, which scarcely overhangs the area; surface faintly marked each side of the sinus by rather remote radiating ribs, which, near the margin, are somewhat distinct. Some impressions of areas supposed to belong to this species, are 2.1" [inches] "long, and .95 high, with a fissure .44 wide at base; deltoidal impression grooved in the direction of the fissure; surface of area flat, slightly incurved at apex and marked by very distinct transverse striæ. Dorsal valve with a low rounded fold, marked (in the cast) by a single small median groove, beak prominent, incurved over a small area."

Locality. Lighthouse, Pt. aux Barques, with *Rhynchonella Huronensis*, *Spirifera Huronensis*, etc.

This well known species is known only by imperfect casts.

I feel quite confident that this is a Syringothyris (and so do Cooper and Girty). The large suite of specimens, 19044, 19265, and 19266, Plate X, Figs. 5, 6 and 7, show a Syringothyris, which is one of the commonest and most characteristic fossils of the series, as Rominger also noticed. It is hardly possible that Winchell could have not found any representative of it, and it is doubtless his species which we figure and his description of *Spirifer pharovicina* agrees precisely with our specimens of Syringothyris, except obviously that the characteristic structure of Syringothyris did not show and is not described by him, but there is nothing inconsistent in his descriptions. In fact he did not found the genus until next year. It is very common and some variation in the height of the area, suggests that a form like *Syringothyris herricki* may be present also.

SPIRIFERA? (cf. *ATHYRIS*) *INSOLITA.* Described as follows, Proc. Acad. Nat. Sci., Phil., 1862, p. 406.

"*Spirifera (?) insolita*, n. sp. Shell large, smooth. Ventral valve with a, broad, concave sinus reaching to the beak, and forming at its lateral margins angles with the shell surface; area short and imperfectly bounded, though the beak is rather high; dental plates very long, reaching the middle of the shell or beyond, and forming with each other an angle of 25°, which is the same as the rostral angle of the mesial sinus.

"Locality. Lighthouse. Pt. aux Barques.

"The species has the short hinge line of Brachythyris, and the smooth surface of Martinia—characters which, with the very long and approximate dental plates render it unique among Spiriferæ."

Schuchert classes this as a Martinia, and it is surely not a Spirifer.

EUMETRIA (?) POLYPLEURA. Plate X, Figs. 13 and 14. Described as follows, Proc. Acad. Nat. Sci., Phila., 1862, p. 406.

"*Retzia Polypleum*, n. sp. Shell of medium size or rather large, cuneate-oval, tumid. Ventral valve with a prolonged, isolated, nearly erect, perforate beak, which projects one-fourth the valve length beyond the dorsal valve, a swollen umbo, and depressed central and anterior region. Dorsal valve rotund, with a subcuneate rostral margin; beak obtuse, closely appressed 'against the ventral valve; umbo ventricose; entire valve with a regular cardium-like convexity; median ridge extending one-third the length of the valve, with a lanceolate occlusor impression on each side of it. Surface marked by about forty small, rounded, radiating ribs. Spires not seen.

"Length, breadth and thickness of a rather small specimen: .70" inches "(100), .58 (83) and .34 (50). Length of dorsal valve .52 (74). Length and breadth of another dorsal valve .69 and .66."

"Locality. Lighthouse, Pt. aux Barques with *Rhynchonella Huronensis*, etc. This species resembles *R. serpentina*, de Kon. (Anim. Foss., 291, pi. xix, 8). but the ventral valve is most ventricose in the umbonal instead of the middle region, and has a nearly erect instead of a straight beak. It differs from *R. vera*, Hall (Iowa Rep. 704, pi. xxvii), in the absence of wings, and in its more erect beak."

These forms seem to be represented by specimens 19073, 19267, 19268. The two specimens which we have figured are from the conglomerate where they are most abundant.

MERISTA HOUGHTONI. Described as follows, Proc. Acad. Nat. Sci., Phila., 1862, p. 407.

"Shell of medium size, subrotund and subtumid. Ventral valve a little produced at the straight, obtuse foraminated beak, somewhat truncate in its contour, along the cardinal slopes, and very slightly elongate in front across the width of the sinus; regularly convex in all directions from the middle, except along the shallow sinus, which takes its origin near the middle of the valve. Impressions of the divaricator muscles longitudinally striate. Dorsal valve circular; beak scarcely projecting beyond the hinge; occlusor impressions small, spatulate, separated by a rostral septum reaching one-fourth the length of the valve; mesial fold represented by an undulation at the anterior margin. Surface of cast smooth.

"Length, breadth and thickness .70 (100), .68 (97) and .36 (51).

"Locality. Lighthouse, Pt. aux Barques, with *Rhynchonella Huronensis*, etc."

It will be noticed that the description does not rule out some allied genera. A number of specimens contain terebratuloid forms, as Sp. 19073.

PLEUROTOMARIA HURONENSIS described, Proc. Acad. Nat. Sci., Phila., 1862, p. 425, as follows:

"*Pleurotomaria Huranensis*, n. sp. Shell rather large, depressed-turbinate, consisting of about four very rapidly enlarging whorls. Body whorl flattened from above, moderately convex above; the base a twisted plane bounded on one side by the slope into a large open umbilicus, on the other, by the sharp whorl marked by eleven raised plications and intervening broad sulci, of which, counting from the umbilicus, the sixth rests upon the carina, and the eleventh is close to the suture. These are crossed by striæ of growth rising from the umbilicus, stretching far forward upon the base, curving backwards and just before reaching the carina, and apparently curving forward again after passing it.

"Height of shell 1.00 'in inches' (100); diameter of base 2.00 (200); transverse diameter of aperture .92 (92).

"Locality. Lighthouse, Pt. aux Barques, in intercalated sandstones of the Huron group.

"This species recalls *Euomphalus carinatus*, Sow., (Murch. Sil. Syst. 616, Pl. VI, Fig. 10)."

Our specimens, 19051, 19070, 19075, agree exceedingly well.

CAMAROTŒCHIA HURONENSIS, described as follows: Proc. Acad. Nat. Sci., Phila., 1862, p. 409:

"*Rhynchonella Huronensis*, n. sp. Shell of medium size, tumid, transversely oval, or nearly circular, with rounded lateral, and cuneate rostral margins. Ventral valve with a straight beak, flattened in the central region, and rather abruptly inflected around the margin toward the plane of the valve; mesial sinus beginning with the last third of the shell-length, and consisting of a sudden depression in the antero-marginal slope. Dental lamellae well developed, very slightly divergent. Dorsal valve with an inconspicuous beak and a mesial fold abruptly elevated and confined to the anterior third of the valve; median septum reaching two-fifths the length of the valve. Occlusor muscular impressions semi-elliptic, lying close to the median septum. Shell structure fibrous. Surface marked with 23 small rounded ribs, of which five occupy the mesial sinus.

"Length of the ventral valve .48 "inches" (100); breadth .58 (121); convexity .10 (21).

"Locality. Lighthouse, Pt. aux Barques, in a hard pyritous sandstone, intercalated in the argillaceous slates of the Huron group.

"Var. *precipua* differs from the typical forms in being more flattened on the ventral side, with mesial sinus consisting of an abrupt deflection of nearly the whole anterior margin of the valve, forming a right angle with the plane of the valve; surface with 18 rounded radiating ribs, of which 6 fall in the sinus; dental plates diverging at an angle of 40°."

Both these varieties can be recognized in Specimens 19051, 19271, 19272 and numerous other specimens of the suite, and are like *R. sappho*, etc., Sp. 19058, Fig. 1 and Fig. 18 of Herriek's Plate XXI.* The forms figured on Plate X, Figs. 8, 9 and 10, are the variety *precipua*.

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ORTHIS VANUXEMI HALL. The shells referred here by Winchell are not quite like the type and are thus described (Proc. Acad. Nat. Sci., Phila., 1862, p. 409). The kindred forms in the Lighthouse section are a little larger. (Sp. 19072.)

"*Orthis Vanuxemi*, Hall (10th Ann. Rep. N. Y. Reg., p. 135). Shell nearly circular, sub-tumid; hinge-line very short. Dorsal valve a segment of a sphere; beak not surpassing the hinge, slightly in-curved; a thick median plate or ridge reaching nearly to the centre of the valve, bisecting the right angle formed by the well developed socket ridges. Ventral valve flat, or slightly concave anteriorly, with a projecting beak; median ridge feeble, extending scarcely to the mid-valve; a barely perceptible trace of the semi-circular divaricator impressions sweeping from the beak to the anterior extremity of the median ridge, in the middle of which space are the two small semi-elliptic occlusor scars; dental plates short and thick; teeth well developed, lying in the hinge-line. One of the casts differs in having one of the occlusor scars half heart-shaped and the dental plates more slender. Surface not fully known; marked by numerous radiating striæ which increase by implantation and bifurcation, and produce a crenulated anterior margin. Shell structure finely punctuate.

"Length .81 (100); breadth .81 (100); thickness .25 (31).

"Locality. Lighthouse, Pt. aux Barques, with *Rhynchonella Huronensis*, etc. This shell is a little more convex in the dorsal and flatter in the ventral than the figures given by Prof. Hall, but none of its characters differ materially from his description. Compared with *O. Michelini*, Lev., as described by de Koninck, it is a little more convex dorsally, and presents circular instead of digitate (from the vascular system?) divaricator impressions upon the ventral valve. *O. Vanuxemi* is described from the shales and shaly sandstones of the Hamilton group of New York and Iowa, the lithographic limestones of Missouri, and from the soft sandstones in Eastern Ohio, regarded as Chemung by Prof. Hall."

DERBYA CRASSA is the present name for *Orthis cremstria*. The forms which Winchell thus referred are described as follows (Proc. Acad. Nat. Sci., Phila., 1862, p. 410):

"*Orthis Crenistria*, Phillips. (Pal. Foss. Corn., etc., p. 66, Pl. 27, Fig. 113),—Hinge line equal to greatest width of shell; ventral valve semi-elliptic with shallow constrictions beneath the cardinal extremities; flat, with an umbonal elevation beginning about the middle and rising to a beak which overlooks a large triangular area inclined at an angle of 45° with the shell plane; dental plates strong, each equal to one-fourth the hinge length, forming with each other an angle of about 60°. Occlusor scars reaching nearly the middle of the shell, closely contiguous, leaving together a ligulate anteriorly acute depression upon the cast. Surface covered by fine radiating striæ, interrupted by distinct or obscure concentric wrinkles. In one specimen supposed to belong here, the surface is cut by a set of sharply-cut, twice dichotomizing striæ—the second set reaching half way, and the third one-third the distance to the beak. Dorsal valve hemispherically convex with sharp striæ and concentric 'wrinkles, like the ventral.

"Length of shell, 1.27 (100); length of hinge line 1.37 (107; length of the dental plates .32 (25).

"Locality. Lighthouse, Pt. aux Barques.

"I can make no distinction between this species and that described by Phillips, from South Devon. The beak, however, seems to be perfectly symmetrical, and in this it differs from *Streptorhynchus robusta* Hall, Sp., from the coal measures of Iowa, as well as from the Punjab examples of Davidson (Quar. Jour. Geol. Soc. Lond., XVIII, p. 30), who identifies the Devon, Iowa and Punjab forms. The Michigan forms differ from all the others in the rugose exterior, giving it sometimes the aspect of *Strophomena rugosa*; but as they at the same time differ among themselves, I am not disposed to hesitate in the identification."

What Winchell seems to have in view are forms like Sp. 19045, 19060, very likely a *Streptorhynchus*, or *Derbya*.

ORTHIS IOWENSIS? described Proc. Acad. Nat. Sci., Phila., 1862, p. 410, as follows:

"*Orthis Iowensis?* Hall. (Io. Rep., p. 488, Pl. 2, Fig. 4.) Some casts in my possession resemble those of the above species. Ventral valve nearly circular, regularly convex, with deep pit in the beak between the dental plates, which in the cast produces a conical projection. Middle region of cast with three faint rounded ridges radiating from the beak to the anterior margin.

"Locality. Lighthouse, Pt. aux Barques."

Perhaps this is represented in specimens 19073.

To this list of Winchell's Rominger adds without giving specific names or descriptions a number of genera which are undoubtedly present, viz.:

Productus. Compare our specimen 19062, probably two species, not very large.

Syringothyris. Compare what we have said above under *Syringothyris pharovicina*. The syringothyrids are among the abundant and characteristic fossils.

Streptorhynchus. The species is probably the same as that referred to *Orthis crenistria* by Winchell, the two names being more or less synonymous. Cf. Sp. No. 19067.

Rhynchospira, is very likely the same as the *Eumetria polypleura*, Cf. Sp. 19073, and Plate X, Figs. 13, 14.

Spiriferina. Most of the specimens being casts we are not able to identify this form with any certainty.

Terebratula. This genus we have not been able to identify. It may have been the Merista.

Cypricardella (barquensis). The hinges not being generally in good state of preservation, the generic references of all the lamellibranchs are more or less uncertain. Compare Sp. 19057. Compare also Cypricardia and Sphenotus below. Winchell also mentions a *Cypricardella barquensis* (Proc. Am. Phil. Soc., 1870, p. 393) as occurring in Northern Michigan, i. e., Huron county, but if from the Lighthouse section he would not have included it in the Marshall. Rominger may have seen the species which we figure as *Microdon reservatus* (Plate XI, Fig. 3).

Schizodus apparently extremely common and abundant. The forms usually resemble extremely those figured by Herrick on plate XVII, of Vol. VII of the Ohio reports. Cf. Sps. 19045 and passim to 19073, 19082, 19260. We figure on Plate XI, Figs. 7 and 8, *Schizodus triangularis*. Many of these shells and many of the Spirifers seem to have been slightly crushed in making the cast, being flattened and cracked on the more tumid part.

Aviculopecten. Pectinoid forms are quite common, see Specimens Nos. 19050 and 19062, but I judge belong mainly under Crenipecten, being similar to *Crenipecten caroli*. Compare the new form figured by Cooper as *Aviculopecten areolatus* (Plate XI, Fig. 1).

Goniatites.

Proetus, the glabellas and pygidia of a species of Proetus are extremely common, more rarely, a cheek spine or bit of the thorax may be found (Specimens 19045, 19280 and 19281, and passim through the suite). It is identified by Cooper as *P. missouriensis* Shumard (Plate XI, Figs. 14, 15) described below. No whole specimen has been found here.

Cyathocrinus. Shorewashed fragments of crinoid stems of more than two species are not uncommon. Mr. Cooper has found one head. (Specimens, 19068, '69, '70, '73.)

Bryozoa. Fenestelloid forms are not uncommon, but so far have been found very poorly preserved. (Specimen 19053.)

Besides the above forms we have obtained in our recent collections, forms like the following species.*

Nautilus strigatus, Sp. 19047 (only a small fragment); compare also Sp. 19053.

Nuculites, Sp. 19056 shows a row of teeth on the hinge, the general shape is much like *Cucullella cultrata*.

Spirifer centronatus Win., Cf. Sp. 19061.

Solen priscus (not solen, solenopsis?). Sp. 19064, 19045, round with flaring ends.

In addition to the re-identification or more specific identifications which have already been mentioned Mr. W. F. Cooper has determined the following species (one of which proved, after figuring, to be new).

*Study has not been careful enough, nor opportunity of identification, and in many cases state of preservation good enough, to warrant any decided identifications as yet.

SPIRIFER DELTOIDEUS Herrick.

1888. *Spirifer deltoideus*. Herrick, Bull. Denison University, Ohio, Vol. IV, p. 27, Pl. 2, Fig. 7.

1895. *Spirifer deltoideus*. Herrick, Geol. Survey, Ohio, Vol. VII, Pl. 15, Fig. 7.

The description of this species as originally given is as follows:

"Shell of medium size, quite gibbous, triangular in outline, hinge equalling the extreme width; anterior margin angulated in the middle, forming with the hinge roughly an isosceles triangle of 45°; hinge apparently not, or but slightly mucronate. Dorsal valve prominently convex along the longitudinal axis, rather strongly arched; beak moderately prominent, fold triangular, rather high, sides of shell sloping rapidly from it toward the sides. Surface covered by nearly sixty small rounded, persistent striæ, which rarely bifurcate near the front. From eight to ten stride fall upon the fold which in spite of its prominence (and because of the similar convexity of the valve) is poorly defined. Ventral valve very convex, provided with a deep, triangular, but narrow sinus and sculptured on the dorsal valve. Width of dorsal valve, 37 mm., height 29 mm.

"All the specimens are casts of separate valves in the sandy parts of conglomerate I. There is reason to accept the suggestion made in the last volume, that this species forms a link between the *S. marionensis* and *S. stratiformis*."

Formation and Locality. In the conglomerate bed at Point aux Barques light, Huron county, Michigan. This species was originally described from the same horizon at the Dugway quarry three miles west of Newark, Ohio, where it is found in conglomerate I. Michigan Geological Survey Collection, No. 19264. (Plate X, Fig. 4 of this report.

AVICULOPECTEN AREOLATUS, n. sp. Cooper [Crenipecten?] Plate XI, Fig. 1.

Shell sub-ovate, oblique to the hinge line; length slightly greater than the height; anterior and basal margins regularly rounded. Left valve slightly convex, reaching its greatest convexity at about one-third the length of the valve from the beak. Hinge line straight, having a length equalling three-fifths of the greatest length of the shell. Beak well defined, projecting slightly beyond the hinge line. Ears triangular, equal, the anterior one meeting the body of the shell at a more obtuse angle. Test ornamented with about 65 sharp rays of unequal size which are crossed with finer concentric striæ. In the anterior portion of the shell the rays are arranged in irregular fasciculi which are crowded out towards the hinge line. On the specimen before us the first 15 rays below the anterior ear have a tripartite division and converge in three bundles towards the hinge line. This feature is sufficient to separate it from any other species of which I know.

Formation and Locality. From the sandstone layer at Point aux Barques light house in the upper Coldwater, i. e., middle Waverly group. Michigan Geological Survey, Collection No. 19278.

EDMONDIA CF. BINUMBONATA A. Winchell. Figured here, Plate XI, Fig. 5.

"Shell medium size, quadrate; height equal to two-thirds the length; basal margin slightly arcuate in the middle, regularly curving into the anterior and posterior extremities. Anterior end straight, regularly rounded underneath the umbonal ridge, forming with the slightly arcuate posterior portion an expanding margin which increases dorsally. Cardinal line nearly straight. Right valve regularly convex, the greatest convexity being in front of the center of the shell. Principal umbonal slope running to the posterior extremity of the ventral border, a shorter one almost equally elevated, extending to the anterior extremity, which is more abruptly elevated than the posterior end. Beaks depressed and incurved. Surface marked by fine, concentric striæ, which are unequally fasciculate, sometimes making conspicuous varices of growth."

This species is not identical with the form described by Winchell as *E. binumbonata*, which is a Schizodus. The hinge line is not short posterior to the beaks as in his description. From *Schizodus subovata* Hall, it may be distinguished by its straight anterior end and depressed beak which does not extend over the hinge as in that species.

Formation and Locality. The specimen here figured is from the light house at Point aux Barques, Huron county, where it occurs in the Coldwater or middle Waverly formation. Michigan Geological Survey Collection, 19277.

SPHENOTUS ÆOLUS Hall. Figured here, Plate XI, Fig. 6.

1870. *Sanguinolites æolus*. Hall. Pal. N. Y., Vol. V, Part I, Prel. Not. Lamell, 2, p. 46.

1875. *Sanguinolites æolus*. Meek. Pal. Ohio, Vol. II, p. 307, PL 16, Figs. la-c.

1885. *Sphenotus æolus*. Hall. Pal. N. Y., Vol. V, pt. I, p. 404, Pl. 66, Figs. 31-35.

188. *Sanguinolites æolus*. Herrick, Bull. Denison University, Ohio, Vol. Ill, p. 70, Pl. 8, Figs. 1, 11.

This species which has been admirably described by Meek in Volume II of the Paleontology of Ohio is stated by him as coming from the Cuyahoga shale at Medina county, Ohio, from the same horizon as at Newark, Ohio. As Orton and Herrick limit the term these beds do not form a part of the Cuyahoga series. At Newark, Ohio, the sandstone beds which almost uniformly form the quarry rock in central Ohio, are a part of the middle Waverly or lower Logan and are at least 40 feet above the typical Cuyahoga, which in Licking county outcrops farther west. In Huron county this form is of value as coming from beds of the same horizon (middle Waverly), and lithological character as outcrops in a north and south line from Portsmouth, Ohio, to a point north of Wooster.

Shell elongate, ovate, posterior end regularly rounded, anteriorly it slopes abruptly from the beak with a distinctly concave outline to the most prominent part of the front margin which is above the middle, narrowly rounded below; basal margin straight or slightly elliptical, sub-parallel to the base; cardinal line nearly straight or slightly convex; beak, small, well defined, depressed, projecting forward and placed about one-seventh the distance from the anterior end of the shell.

Surface marked with rather distinct concentric lines with furrows and ridges which have a tendency to become well defined anteriorly.

Formation and Locality. From the middle Waverly or lower Marshall at Point aux Barques light house. Mich. Geol. Survey Coll. No. 19260.

SCHIZODUS TRIANGULARIS, Herrick. Figured, Plate XI, Figs. 7 and 8.

1888. *Macrodon ? triangularis*. Herrick; Bull. Denison University, Ohio, Vol. Ill, p. 74, Pl. VIII, Fig. 8.

1888. *Schizodus triangularis*. Herrick; Bull. Denison University, Ohio, Vol. IV, p. 116, Pl. VI, Figs. 10, 13.

1895. *Schizodus triangularis*. Herrick; Geol. Survey, Ohio, Vol. VII, Pl. XVII, Figs. 10, 13.

Shell medium, subtriangular in outline, convex; hinge line very short; anterior end slightly convex, contracted beneath the beak and rounded below, ventral line gently convex anteriorly, incurving anterior to the umbonal ridge; posterior margin nearly straight, very oblique to the hinge; post-umbonal slope abrupt, slightly concave, anteriorly the umbonal ridge is gently rounded and depressed anterior to the ridge, producing a deflection in the ventral margin; umbones rather broad, depressed, projecting beyond the hinge line.

This species is more nearly related to *S. aequalis* Hall, than any other form, but the beak is not sub-central as in that species, and the posterior margin is less produced.

Formation and Locality. Abundant in the middle Waverly or lower Logan sandstone above the conglomerate at Point aux Barques lighthouse, Huron county, Michigan. This species is also found in the same horizon at Granville, Licking county, Ohio. Michigan Geological Survey Collection 19256, 19257.

SCHIZODUS BINUMBONATA cf. *ÆQUIMARGINALIS* Winchell. Proc. Acad. Nat. Sci. Phila., 1862, p. 413. Figured here; Plate XI, Fig. 9.

The original description reads as follows:

"Shell of moderate size, rotund quadrate, very tumid. Hinge line short, posterior to the beaks; posterior margin forming with it a very obtuse angle; anterior slope straight, forming a rounded right angle with the slightly curved ventral border which is nearly parallel with the hinge line, and joins the posterior slope by a regular curve. Beaks depressed and incurved; greatest thickness through the middle of the shell; principal umbonal slope running to the posterior extremity of the ventral border; a subsidiary one running to the anterior extremity; between these the surface is subcylindrical; anterior to them it descends abruptly to the anterior margin, while behind them it sinks at first rather abruptly, and near the posterior border presents a little flattening.

Surface (of cast) marked by eight or ten concentric furrows. Anterior lunule excavated.

"Distance measured along the principal umbonal slope (in inches) .85 (100); length from anterior to posterior extremity .85 (100); anterior slope .59 (69); convexity of right valve .24 (28); angle between anterior cardinal slope and principal umbonal line 70°."

Formation and Locality. The type species is described as coming from Marshall. The form here figured is from the Upper Coldwater (Cuyahoga) as that term is now understood; from Point aux Barques lighthouse, Huron county, Michigan. This is equivalent to the middle Waverly or lower Logan of Ohio. Michigan Geological Survey Collection, 19262.

PROTHYRIS MEEKI, Winchell. Plate XI, Fig. 10.

1875. *Prothyris meeki*, Winchell (Ms.) Pal. Ohio. Vol. II, p. 305, Pl. XV, Fig. 2.

1888. *Prothyris meeki*, Herrick, Bull, Denison U., Ohio, Vol. Ill, p. 66, Pl. VIII, Fig. 7.

1888. *Prothyris meeki*, Herrick, Bull, Denison U., Ohio, Vol. IV, Pl. IV, Fig. 2.

1895. *Prothyris meeki*, Herrick, Ohio Geol. Survey, Vol. VII, Pl. XVI, Fig. 2.

Shell varying from narrowly elongate to elongate; rhombic in shape, greatest width about one-third the length; dorsal and ventral margins sub-parallel, the lower margin being either straight or slightly arcuate, while the cardinal line in normally preserved specimens is convex, the greatest convexity being usually about one-third distant from the posterior end; umbonal ridge well defined trending

towards the ventral portion; ventral portion of the umbonal ridge depressed from the central portion of the basal margin to the Beaks; beak depressed, situated about one-sixth the distance from the anterior end.

Surface marked with concentric lines of growth.

Formation and Locality. This species is found in central Ohio in strata either above or below the conglomerate II in the Waverly. The specimen here figured is incompletely preserved. It is from the sandstone beds over the conglomerate at Point aux Barques lighthouse, Mich. Geol. Sur. Collection No. 19261.

PROETUS MISSOURIENSIS, Shumard. Plate XI, Figs. 14, 15. 1855. *Proctus missauriensis*, 1st and 2d Geological Rep. Missouri, p. 196.

1862*.* *Proetus auriculatus*, Hall, 15th Rep. N. Y. State Cab. Nat. Hist., p. 107, and Pal. N. Y. Vol. VII, p. 133, PI. Ill, Fig. 32.

1895. *Proetus auriculatus*, Herrick, Geol. Surv. Ohio, Vol. VII, Pl. XIV, Figs. 14, 15.

For description of this species the student is referred to the preceding publications. The glabella and pygidium (head and tail shields) are figured here on account of the value in connection with the associated fauna. In Licking county, Ohio, it only occurs in the freestones of the middle Waverly between conglomerate I and II. Its position at Point aux Barques lighthouse is just over the conglomerate where it is found very abundantly along with *Schizodus triangularis*. The specimens here illustrated came from that horizon and place. Mich. Geol. Sur. Collection, 19280, 19281.

ORTHOCERAS BARQUIANUM, Win. described as follows, Am. J. Sci., (Second series) XXXIII, p. 356.

"Septate portion of shell more than 41/4 inches long; greater apical angle (i. e. the one formed by the sides which are not compressed), about 10°; tranverse section an ellipse whose minor axis is to the greater as .35: .50 = 1.43; septa somewhat oblique, making an angle of 8° to 10° with a transverse plane; most elevated near one extremity of the longer diameter; amount of concavity and position of siphon unknown; distance between the septa about one-fifth the greater axis at the same place. No surface markings evident from an examination of casts.

"Locality. Near the lighthouse at Point aux Barques in a hard bluish sandstone embraced in the shales of the Huron group. (See Huron group, (c) of the preceding table).

"This species may possibly prove identical with the preceding, but its apical angle is somewhat less, its septa more oblique, its section more eccentric, and its geological position considerably lower."

In the shaly beds of the Lighthouse Point section we find much the same fauna as that which is from the sandstone layers, mainly D. of p. The Producti and *Orthis vanuxemi* or Chonetes are more prominent. We have also Camarotœchia and apparently ostracoda. Sp. 19076, 19077. There are also flattened spirifers (Sp. 19075-19078).

A very calcareous facies shows Syringothyris and crinoids still abundant. The very purest shale is, however, nearly destitute of fossils. Among the bryozoa there are two types well recognized though poorly preserved, the one like *Fenestella*, the other rounded branching forms, Sp. 19082, more of the *Stictopora* type preserved only in casts.

Though not a fossil, the interesting bit of black shale, almost coal, rounded and polished like jet, which occurs as a fragment in the conglomerate should be noted in this connection.

Taking the lamellibranchs first, the abundance of Schizodus, and Pecten forms, indicate the Carboniferous. Among the more obscure forms, the thin shelled casts of forms like Sanguinolites, Cypricardella, Sphenotus, Solon or Solenopsis, thin gaping mollusks with anterior beaks is also according to Zittel indicative of the Carboniferous.

Among the brachiopods the Terebratula, Retzia and Merista forms, are too uncertain in generic identification, and too little characteristic anyway to count for much, though the Athyris or Martinia is rather Carboniferous.

The numerous species of Spirifers, have both Devonian and Carboniferous forms, though the presence of so many forms with a striated sinus, leads one to think of the Carboniferous. The Spiriferina would point the same way; the Syringothyris is even more strongly indicative. The trilobite almost certainly *Proetus missouriensis* points to the early Carboniferous or Devonian. The Orthis points the same way, though the large flat forms like *O. michelini*, and the forms like Streptorhynchus and Derbya, are also early Carboniferous.

The Rhynchonellas mean little, but the Producti are significant of the Carboniferous. Being rather small we think first of the lower Mississippian.

The Orthoceras is pre-eminently early Palæozoic, though abundant yet in the Carboniferous.

Taken altogether we incline to override Winchell's judgment* and assign this horizon as well as those above to the Carboniferous. On this connection we must not overlook the pebble of coaly shale. If this be from the Genesee, the Devonian black shale, it indicates that some part of the Devonian, had been turned to coal, elevated and eroded before the epoch of the Lighthouse conglomerate. This test is commonly used in Archæan geology for making the greater divisions.

We have noticed in Chapter II that Winchell in assigning these strata to the Devonian seems to have done so on the principle of giving your opponent the most possible. On a doubtful identification of four species, he yields this much to those who wished to claim the whole series as Devonian, saying "that the equivalencies of these rocks are not very precisely indicated from palæontological data."

When we compare with Herrick's lists, we see that we can find possible synonyms for almost every one of our forms in his lists of forms within 30 feet above and below Conglomerate I, at the base of his division II or Kinderhook. Yet the lists and forms do not appear to be precisely the same. The extreme wealth of fauna, and especially the occurrence of different species of the same genera, suggests an intermixture of two faunas in process of migration (and rapid evolution?) so that, for example Syringothyris may have existed a little earlier in Michigan than in Ohio, and Orthoceras like *O. rushensis* a little later. Plate X, Figs. 3 to 10, 13, 14 and Plate XI, Figs. 1, 5, 6, 7, 8, 9, 14, 15, give a view of some of the more characteristic forms.

*A. Phil. Soc., 1870, p. 386.

(3). **Huron City zone.**

No fossils appear to have been collected from this belt by Winchell, and he probably* considered these sandy beds at Huron City as equivalent to the quarry beds at the base of his Marshall, whereas they are really some 84 feet below the quarry beds. Rominger notes a Rhynchonella as abundant, and Productus as also present. He mentions *Fucoides Cauda galli?* on surface of the same bed.

CAMAROTŒCHIA (RHYNCHONELLA) CAMERIFERA, Sp. 19036, 19273, 19274, Plate X, Figs. 11, 12; many specimens agree better with this species than any other described by Winchell, and are very abundant, somewhat smaller than the rhynchonellas of Lighthouse Point. Others show hardly any mesial sinus, and otherwise agree with Winchell's descriptions of other species.

*Report 1860, p. 74.

The original description of the species is given by Dr. Winchell:

"Shell of moderate size, tumid; beak of ventral valve projecting and slightly upturned; cardinal slopes straight, at right angles; sides of the shell rounded; front margin similarly rounded or somewhat straight, not infrequently produced on one side of the mesial sinus. Dorsal valve nearly circular, a little more covered than the ventral, most convex anterior to the middle, and rather abruptly bent down in front. Ventral valve with a shallow sinus, which extends back about one-fourth the length of the valve, corresponding to the fold in the dorsal valve; most convex between the beak and the middle; dental plates parallel, well developed, teeth at right angles, elongate, growing stouter anteriorly, with handsomely crenulated margins; mesial partition of the dorsal valve, extending nearly one-half its length, thickening near the beak, to give place for the excavation of a small chamber near the septum. Shell with 20 or 21 (a variety ? with 16) sharp plications, of which three or four are comprised in the mesial sinus; these are crossed by a few squamose concentric wrinkles; shell structure fibrous.

"Length of an average specimen" [inches] ".38 (100); breadth .34 (90); thickness .19 (50)."

Formation and Locality. The type species is found most abundantly on the road leading west from Grindstone City and in the valley of Willow river about 3 miles south of Huron city, with *Romingerina julia*. The species here figured are from the bed of Willow River near Huron City.

"Locality. Point aux Barques, in a conglomeratic ferruginous sandstone overlying the gritstones of the Marshall group—myriads of casts sometimes forming, with *Centronella julia*, the whole mass of the rock.

"The small chamber in the mesial septum of the dorsal valve is an interesting and unique character. On a similar cameration of the septum of the ventral valve of some Cyrtiæ the genius Cyrtina has been founded; and Prof. King established his Camarophoria on the formation of an arch in the ventral valve by the approximation of the dental planes.

"This species has the external appearance of the young of *R. increbescens*, but amongst thousands, none attain proportions very different from those given above."

This associated with *Romingerina julia*, makes a well marked zone, 220 feet below the top of the Lower Marshall and forty feet above the grindstone beds.

Productus is still small.

Scolithus, flattened, nearly vertical tubes, worm borings or as likely tracks of some lamellibranch. Sp. 19036.

Schizodus triangularis, smaller than some at Lighthouse Point, but almost exactly like others, about 20 mm. long, Sp. 19037.

Myalina, cf. *whitfieldanus*, Sp. 19037, a small pointed form.

Sphenotus? Sp. 19037.

Crenipecten winchelli? There are a number of pecten fragments. Sp. 19039, and it is characteristic that the ribs are bifurcated. What seems to be a smaller species is more marked by squamous lines of growth. These are not Lyriopecten, but may be Crenipecten.

There is also the cast of the umbilicus of some gastropod like *Pleurotomaria*? Sp. 19041.

There is a small *Nucula* form about like *N. iowensis*. Sp. 19040. Specimens 19038 and 19042 are fossil forms that I cannot determine, even approximately.

MICRODON RESERVATUS Hall. Figured here. Plate XI, Fig. 3.

1870. *Microdon reservatus*, Hall, Pal. N. Y., Vol. V, Part I, Prel. Not. Lamell., 2, p. 33.

1885. *Microdon reservatus*, Hall, Pal. N. Y., Vol. II, Pt. I, p. 312; Pl. 74, Figs. 11-13.

1888. *Microdon reservatus?* Herrick, Bull. Denison Univ. Vol. Ill, p. 75, Fig. 14.

1895. *Microdon reservatus*, Herrick, Geol. Survey, Ohio, Vol. 7, Pl. 17, Fig. 9.

This species which is found abundantly in the freestones of the middle Waverly or lower Logan, Licking county, Ohio, and in the valley of Willow river, south of Huron City, Michigan, is rather above medium size, rhomboid ovate, slightly convex; beak (situated two-sevenths from the anterior end of the shell) depressed small, projecting little above the hinge line; anterior end declining somewhat abruptly from the beak; cardinal line and ventral margin gently curved; anterior and posterior muscular impression situated in the upper half of the shell connected by a pallial line.

Formation and Locality. From the valley of Willow river just south of Huron City, Michigan, in yellow sandstone beds of the lower Marshall or middle Waverly. Also found in Licking county, Ohio, in strata of the same age and character. Michigan Geological Survey Collection 19258. Similar forms occur in blue shales. Sp. 19043. Sp. 19106 is in this division also, and is perhaps a rush impression. The extreme abundance of rhynchonelloids reminds one of the zone of *Romingerina julia*, a little higher up.

(4). **Point aux Barques zone**; 85-260 feet below the top of Lower Marshall.

We can distinguish here two or three slightly different faunal stages but as they cannot be certainly distinguished in Winchell's descriptions we are obliged to group them, and there is after all no great difference. Winchell describes a number of Rhynchonellas, Proc. Acad. Nat. Sci., Phil., 1862, pp. 407-409, viz.:

Rhynchonella camerifera, described above and figured here on Plate X, Figs. 11, 12.

RHYNCHONELLA SUBCIRCULARIS, characterized by lack of mesial fold, described as follows:

" n. sp. Shell small, cuneate-rotund, subtumid. Ventral valve, unknown. Dorsal valve with a blunt depressed beak, equalling the hinge, a moderately elevated umbo from which the surface slopes with gentle convexity to the lateral and anterior margins, and abruptly, with slight excavation, toward the superior portion of the rounded hinge-margins. Surface marked by about 32 fine rounded plications, which reach from the margin half way to the beak. Mesial fold wanting. Mesial septum extending one-fifth the length of the shell.

"Length of dorsal valve .25 (100); breadth .259 (100); convexity .08 (34).

"Locality. Grindstone quarries, Point aux Barques, with *R. camerifera*. This species is a close analogue of *R. radialis*, Phillips, sp. Geol. Yorks. 223, Pl. XII, pp. 40, 41, from the Carboniferous limestone of Bollard."

ROMINGERINA [CENTRONELLA] JULIA, described Proc. Acad. Nat. Sci., 1862, p. 405.

"Centronella julia, n. sp. Shell small, nearly circular, ranging from slightly elongate to transverse, and squarely rounded; both valves with regular lens-like convexity, sometimes with a gentle ridge running the length of the ventral valve, and a slight sinuation near the margin of the dorsal. Ventral valve with a moderate beak, circularly foraminated, turned up at a right angle, covering the beak of its fellow. Area entirely wanting. Shell obsoletely striate concentrically, and having a minutely punctate structure. Apophysary system as follows: A delicate ribbon-like loop, originates from the stout blunt crura of each side of the socket valve, having its flat sides at first vertical; the two branches of the loop proceed at first in lines parallel or a little convergent, and then gradually diverge, widening as they proceed, and assuming an inclined position, until, approaching the front of the valve by a regular curvature, the lower edge has become anterior, giving the band an angle of 30° with the plane of the shell; approaching the median line the band rapidly widens and the front margin is drawn forward in a long acumination, while the inner margin is regularly concave, except that near the median line it turns abruptly forward so as to meet that line at an acute angle. The loop thus forms an urceolate figure on its inner margin, and on the outer a somewhat oval one truncated behind and attenuately acuminate before. In the median line where the two branches meet, both are suddenly deflected downwards, forming a double vertical plate, not quite reaching the ventral valve, the upper edge of which, when, viewed from the side, is flatly roof-shaped, while the lower edge describes two convexities, the greater anterior, leaving a notch between them. The surfaces of the loop and median plate are covered with minute obliquely conical pustules, in some places seeming to become spinulous. The casts exhibit on the ventral side a delicate impressed line extending from the beak to the middle, and on the right and left of this a fainter one; on the dorsal side a median impression with two fainter ones on the right, and two on the left—the median terminating rostrally upon a small pyramidal process (filling the beak of this valve) separated by a short slit (made by the socket ridge) from a smaller isolated process on each side.

"Length, breadth and thickness of an average specimen: .31 (100), .29 (94) and .15 (48)."

Locality. Grindstone quarries, Point aux Barques, in a conglomeritic ferruginous sandstone overlying the gritstones of the Marshall Group, abundant. Figured and assigned to Cryptonella by Hall, Am. J. Sci., XXXV, p. 400, but reclaimed by Winchell in the Proc. Acad. Nat. Sci. Phil., 1865, p. 123, and the figure used again in his Geological Studies. Figured also by Hall, Pal. New York, IV, 1867, p. 419. Pl. 61A. Figs. 41-46; Herrick, Bull. Denison Univ., Vol. Ill, p. 49, Pl. II, Fig. 5. Made type of this genus and named after State Geologist C. Rominger by Hall and Clarke, "Introduction to study of Brachiopods," Pt. 2, Pl. 52, Figs. 14, 15 and Pal. N. Y., Vol. VIII, Pt. 2, Pl. 79, Figs. 28-30. It occurs with *Camarotœchia Camerifera*, and makes a marked zone, to which belong specimens 19012, 19094, 19092.

PTERINEA CARDINATA (Cf. Sp. 19094). Described Proc. Acad. Nat. Sci. Phila., 1862, p. 412.

"*Pterinea cardinata*, n. sp.—Shell small, hinge line extremely elongate, posteriorly terminating in an angle of 40°, separated by a slight sinuation from the body of the shell; ventral margin transversely semi-elliptic; anterior wing short, saccate; anterior margin forming with dorsal line an angle of about 45°. Beak flattened, not elevated above the hinge; umbonal slope terminating at the middle of the ventral border, opposite which is the greatest width of the shell; descent from the umbonal slope to the antero-ventral border very abrupt. Surface of cast showing numerous faint concentric grooves which are most conspicuous in the postumbonal region.

"Length of hinge .65 in. (100); greatest width of shell .21 (32); convexity of right valve .06 (9); length of anterior wing .06 (9).

"Locality. Grindstone quarry, Point aux Barques, with *Camarotœchia* (*Rhynchonella*) *camerifera*, etc.

"This species differs from *P. elongata*, Goldf. (Petref. Germ. i, 135 Taf. CXIX 5), in having a much smaller body, and less distinct from the alate extremities/."

MYALINA PTERINÆFORMIS, described same page.

"n. sp. Shell small, equivalve, obliquely elongate, with an alate posterior expansion, which is suddenly thickened above to form the basis of the straight elongated hinge line. Beaks subterminal, obtuse, incurved, elevated a little above the hinge; midumbonal slope making an angle of about 35° with the dorsal margin; from the upper portion the declivity is steep to the hinge on the posterior side, while on the anterior side the shell swells out into a sort of pouch, projecting beyond the beak; posterior margin of shell showing a sinuation just below the hinge, from which a regular curve sweeps around to the anterior side. Shell thin, with fine incremental lines.

"Length of shell along dorsal margin .44 inch (100); length from beak along midumbonal slope .38 (86); distance from beak to anterior extremity .10 (22); to posterior .34 (78); diameter of shell through umbo .12 (24).

"Locality. Point aux Barques, from a friable and ferruginous sandstone overlying the grindstones."

BELLEROPHON GALERICULATUS, Win. Proc. Acad. Nat. Sci. Phila., 1862, p. 426 (also Report 1860, p. 80) described as follows:

"*Bellerophon galericulatus*, n. sp.—Shell, small, globose, involute, ecarinate, exumbilicate, longitudinally striate, and deeply notched. Dorsum broadly and regularly rounded, without any evidences of a band, except in approaching the aperture of adult shells, where a rather broad band with ventrally concave incremental lines can be faintly traced. Aperture crescentic, not suddenly expanded strongly auriculate, with the ears hanging detached from the inner whorl. Notch infundibuliform, deep and broad, obtuse, its sides reaching to the tips of the auriculations. Umbilicus closed, scarcely indented. Dorsal and dorso-lateral surface marked by about 28 longitudinal, sharply raised striæ, separated by much wider flutings, and not perceptibly modified by the dorsal band until within half a whorl of the aperture of the adult shell, when the two middle striæ become slightly raised and enlarged, and the entire set simultaneously die away. Between these striæ and the umbilical point similar striæ diverge spirally and irregularly until intercepted by the former set, or by each other. Cast smooth, perforately umbilicate.

"Average diameter of adult .47 inch (100); height of last whorl at the aperture .26 (55); height of aperture .35 (74); depth of notch .22 (47); width of peripheral belt at notch .06 (13); separating distance between tip of auriculations and inner whorl .10 (21); number of striæ in one-tenth of an inch (ten), and this is the same in young and old specimens. Diameter of largest specimen seen .53.

"Localities. Marshall, Battle Creek, and nearly all other Southern outcrops of the Marshall Sandstone.

"The shell bears a close resemblance to *B. Urei*, of authors, but seems to differ in essential points, as follows: From *B. Urei*, de Kon. (An. Foss. 356, XXX. 4) in being only half the size, having the dorsal belt elevated instead of compressed, in its very deep notch, less proportional width and distinct auriculations; from McCoy's *B. Urei* (Brit. Pal. Foss. 554) in having the striæ much narrower than the intervening grooves and not at all modified by the dorsal band, and in having the width of the aperture less than the diameter of the shell. Prof. Phillip's figures differ in the absence of auriculations, and in the lateral striæ. To Fleming's original description I have not access."

This form is figured by Herrick, Bull. Denison Univ., Vol. Ill; p. 89; Pl. II, Fig. 34; Plate IX, Fig. 32.

Above forms all belong in this zone, the locality of other forms are more uncertain, viz.:

CARDIOPSIS MEGAMBONATA, Proc. Acad. Nat. Sci., Phila., 1863, p. 17, 1862, p. 417.

"The specimen here referred is many times larger than the types of the species, being of the size of *C. crenistriata*, Win., from which it differs principally in the coarser and more rigid ribs and more prominent beak.

"The ribs in the Burlington specimens do not increase in number with age, and scarcely increase in size; the intercostal spaces are flat, gradually widening.

"Height from beak to ventral margin .91 inches (100); length .85 (97); thickness of left valve .55 (60).

"*Cardiopsis Megambonata*, n. sp.—Shell very small, ovate, with an elevated little incurved, nearly ventral beak, gibbous umbo and regularly rounded margins, of which the ventral is most abruptly so. Slopes from the umbo convex in all directions to the very margin. Anterior and posterior cardinal margins similar and equal. Surface of casts striately ribbed, most distinctly so toward the ventral border, and in some cases marked by rather strong concentric wrinkles toward the pallial margin.

"Height from beak to ventral margin .25 inch (100); length from posterior to anterior margin .23 (92); convexity of left (?) valve .11 (44).

"Locality. Grindstone quarries, Pt. aux Barques, with *Rhynchonella camerifera*, etc."

RHYNCHONELLA BARQUENSIS, Win. described Proc. Acad. Nat. Sci., Phila., 1862, p. 408, as follows:

"*Rhynchonella Barquensis*, n. sp. Shell small, transversely oval, thin. Ventral valve with a moderately prominent beak and slightly curved cardinal slopes; greatest tumidity near the beak, from which the surface descends in right and left margins. Dorsal valve flattish, most inflated in the middle. Mesial fold and sinus small, traceable one-fifth or sixth the length of the shell, embracing two or three sharp plications, of which the entire surface of each valve receives about 12 or 13. Dental plates of ventral valve parallel; mesial septum of dorsal valve camerated as in *R. camerifera*.

"Length .30 inches (100); breadth .32 (107); thickness .13 (43).

"Locality. Grindstone quarries, Pt. aux Barques, with *R. camerifera.*"

CAMAROTŒCHIA HUBBARDI, Win., Proc. Acad. Nat. Sci., Phila., 1862, p. 407. Described as follows:

"*Rhynchonella Hubbardi*, n. sp.—Shell small, subquadrantal in outline; cardinal slopes straight, forming a right angle or more; lateral extremities about midway of the shell; anterior border gently curved; the two valves equally convex; ventral valve most tumid near the beak, the dorsal in the middle. Surface marked by 21 small rounded radiating plications. Mesial sinus represented by a broad shallow flattening of the mid-frontal slope of the ventral valve, occupying the two middle fourths of its width, and corresponding to 8 or 9 plications. No fold perceptible in the dorsal valve, but a shallow depression extends from the beak about one-third of the length of the shell, corresponding to the extent of the median partition beneath it. Dental plates of the ventral valve well developed, diverging at an angle of about 30°. Shell thin, fibrous.

"Length of a ventral valve .26 inch. (100); breadth .31 (119); convexity, .08 (31).

"Localities. Marshall and the grindstone quarries at Pt. aux Barques, belonging to the Marshall group.

"The dorsal valve greatly resembles that of *R. circularis*."

SANGUINOLITES BOREALIS, Proc. Acad. Nat. Sci., Phila., 1862, p. 415, thus described:

"*Sanguinolites borealis* n. sp.—Shell rather small, ventricose, transversely elliptic; beak somewhat projecting and incurved, less than one-fifth the shell length from the anterior extremity, with a lunuliform excavation in front of it; dorsal margin straight, ventral margin slightly arcuate; posterior extremity regularly rounded; anterior sharply bent in front of the lunulae, from which it slopes with a truncate backward curve to the ventral border; umbonal slope extending diagonally to the infero-posterior margin, somewhat anguiated behind the beak, and inflected toward the cardinal region. Surface of shell of northern specimens unknown; cast showing several distinct concentric grooves. Shell of southern specimens thin, marked both with concentric and minute radiating striæ. Greatest height of shell along the perpendicular from the beak; greatest convexity in the middle of the same line.

"Length 1.10 inch. (100); breadth .44 (40); thickness of right valve .15 (44).

"Locality. Grindstone quarries, Pt. aux Barques above the gritstones, and Moscow, Hillsdale county.

"Distinguished from *S. unioniformis* and *S. Marshallensis* by its terminal beaks, greater relative gibbosity, greater length and its posterior attenuation."

We identify this species somewhat doubtfully with the form figured in Plate XI, Fig. 11, which, however, conies from a higher horizon.

BELLEROPHON BARQUENSIS, Proc. Acad. Nat. Sci., Phila., 1862, p. 427, described as follows:

" n. sp. Shell small, globose, involute, rapidly enlarging, dorsally depressed; umbilicus small, but deep; dorsal broadly convex, with a distinct raised band; sides sharply rounded into the umbilicus; aperture crescentic, expanded with a deep broad construction behind it, notch deep and narrow. Surface marked by fine, regular, longitudinal lines, which cover the band as well as the other parts. Diameter .48 inch. (100); transverse diameter of aperture .54 (112); height of aperture to middle of umbilicus .27 (56).

"Locality. Pt. aux Barques, above the gritstones.

"Most nearly resembles *B. Michiganensis*, but the apertural construction and single set of striae render it easily distinguishable."

It is quite likely that Winchell assigned the form here described at first to *B. galericulatus* as in his latest list he does not mention *B. galericulatus* from northern Michigan.

(*Dentalium barquense*, Proc. Acad. Nat. Sci., Phila., 1862, p. 425, 1865, p. 131 is of uncertain affinities and should be expunged.)

(*Sanguinolites strigatus*, Proc. Acad. Nat. Sci., 1865, p. 129, was undescribed, and specimen lost and should be expunged.)

Lepidodendron, Proc. Acad. Nat. Sci., Phila., p. 387, 1870, mentioned but not described.

Productus concentricus, Proc. Acad. Nat. Sci., Phil., 1862, p. 411, fragments only of a productid from the grindstone quarries which may not be this species, and were not described. We have also Productus fragments from the *Romingerina julla* zone, Sp. 19094.

Chonetes illinoisensis smaller than typical, Proc. Acad. Nat. Sci., Phil., 1863, p. 5; 1865, p. 116.

[CTENODONTA] (NUCULA) SECTORALIS, Proc. Acad. Nat. Sci., Phil., 1862, p. 418, described at first as Nucula, and corrected, Proc. Acad. Nat Sci., Phil., 1865, p. 129, but now all the Ctenodontas are referred to Nucula.

" n, sp.—Shell rather small, ventricose, sectoriform, with nearly central beaks. Anterior cardinal slope straight; posterior, nearly so, making with the former an angle of 88° to 91°; ventral border subcircular. Beaks prominent, acute, direct, incurved. Anterior hinge plate with about 17 teeth; posterior with about 13, much smaller. Adductor scars subterminal, profound, roundly, oval. Surface of casts perfectly smooth.

"Length .86 inch. (100); height .74 (86); thickness .44 (51); distance from beak to line joining extremities .40 (46); length of anterior end .51 (59); of posterior end .35 (41).

"Locality. Battle Creek and Grindstone Quarries, Point aux Barques."

NUCULA STELLA, Proc. Acad. Nat. Sci. Phila., 1862, p. 419, abundant in the lower peanut conglomerate, Sp. 19032, with *Nuculana bellistriata*, described thus:

"n. sp. Shell very small, elliptic-ovate, with subcentral beaks. Anterior cardinal slope arched, posterior nearly straight, extremities rather sharply rounded; ventral side semi-elliptic. Anterior hinge plate with 17 minute, acute teeth; posterior with 5, angulated in both cases towards the beak. Beaks a little attenuated near the extremity, curved inwards and backwards. Pallial line entire, connecting the muscular scars, which are oval, and situated considerably above the middle line of the shell. Shell thin, with delicate concentric striæ.

"Length .33 inch. (100); height .24 (73); thickness .14 (42); length of anterior end .20 (61); of posterior end .13 (39); distance from beak to line adjoining extremities .14 (42); length of anterior end .20 (61); of posterior end .13 (39); distance from beak to line adjoining extremities .14 (42).

"Locality. At every outcrop of the formation in the southern part of the state. Also at the Grindstone Quarries, Point aux Barques.

"This beautiful little shell has affinities with *N. ventricosa*, Hall, (Iowa Rep., 716, Pl. 29, Fig. 4), from the coal measures of Iowa. It is easily mistaken for the young of *N. hubbardi*, but is proved distinct by its more rounded sides and fewer teeth, as well as by its occurrence in a region of the state where the larger species is as yet unknown."

CYTRERE CRASSIMARGINATA, Proc. Acad. Nat. Sci. Phila., 1862, p. 429, thus described.

"*Cythere Crassimarginata*, n. sp. Carapace minute, ventricose, regularly oval, microscopically wrinkled—scrobiculate; hinge line impressed, and hinge margin a little hollowed; valves margined by a smooth bead, which projects slightly beyond the general surface, behind which is a small groove; cast smooth, but margined by a raised band terminating near the hinge anteriorly and posteriorly.

"Length .08 inch; breadth .05.

"Localities. In the Marshall Sandstone, at Battle Creek, Liberty (Jackson county), Moscow, near Napoleon and at the Gritstone Quarries, at Point aux Barques, with *Rhynchonella camerifera*."

Also near Wheatfield. Cooper has noticed them.

"Beside the species already enumerated from the Marshall group there yet remain a few too imperfect for adequate description, or belonging to classes not yet investigated. Among these are Lepidodendron and Neuropteris?; a coralline structure, like Fistulipora encrusting foliaceous or branching, with minute, short, crowded polygonal cells .0088 of an inch in diameter, without visible lamellae, but with some indications of transverse floors; some undetermined Lamellibranchs; two sorts of Chiton-like scales; two or three Nautili, of which one is nodulous; and sundry remains of spines, teeth and bones of fishes."

Munsteroceras [Goniatites] oweni, Cf. Win. Am. J. Sci. XXXIII, 364, Sp. 19014; we can recognize this form probably, as well as other species of Goniatities in the fargments from the Grindstone quarries. They seem to have been originally beach broken fragments, and are at times right in the overlying conglomate (Sp. 19017), and also in nodules in the sandstone (Sps. 19014-19016).

Goniatites propinquas and—

Goniatites shumardianus, described in the same article, all are forms like his, with simpler sutures than occur higher up in the series.

Orodus a genus of fish, and—

Catamites, a rush, are added by Rominger.

From our collections we may add:

Orthoceras, two species, Sp. 19033 from the lower peanut conglomerate is a large form; Orthoceras, Sp. 19014, has marked rings about 8 to 1 inch.

Crinoid stems, are abundant in certain layers, and two, or more species are represented. Some of the stems are very large.

Pteurotomaria? Sp. 19014. Fragment.

Spirifer, Sp. 19014 a small depressed form.

Ctenaeanthus? Sp. 19013 and 19014. These hollow spines have the rear angles much sharper than any species I know.

Principal cusp of a shark's tooth, Sp. 19016. Cf. Orodus. The teeth known as Orodus and the spines as Ctenacanthus have been supposed to belong to the same fish.

Melonites is reported by Geo. H. Girty.

As we go up toward the Point aux Barques sandstone fossils become scarcer, and yet no essential change in the character of the fauna is noticed. Rominger recognized the cast of a Rhynchonella, and an impression of a Goniatite right under the Point aux Barques sandstone. Of the fauna between the Point aux Barques sandstone and Flat Rock we know little.

One specimen, 19204, not absolutely in place shows *Schizodus*, or *Posidonomya*, and coaly bits of vegetation.

Almost directly beneath the heavy beds of Flat Rock Point (Point au Pain Sucre), comes a peanut conglomerate, and ripple marked beds, with traces of rushes, a Goniatite, Sp. 19016, and as Rominger remarks (Vol. Ill, p. 71), *Camarotœchia camerifera.*

Somewhat uncertain as to their exact position in the column, and not assuredly in place are: Sp. 19089, a coarse, friable, very red sandstone containing—Productus, *Orthis michelini*, and a Merista or Cryptonella-like form. Sp. 19090 which appears to be just about the horizon of the Port Austin sandstone, and is a very similar rock to 19089, and beside the same Merista form (cf. *Athyris ohioensis*), apparently contains a Schizodus and *Crenipecten caroli*, gastropods and Rhynchonella, but the fossils in these red sandstones drop to pieces as you look at them, and to get the best results should be studied thoroughly by a competent palæontologist upon the ground. Mr. Cooper has not visited them.

Taking this fauna as a whole, we may notice as characteristic the abundance of rhynchonelloids, and fish fragments and coaly remains. Many of the specimens, especially the Goniatites, and fish remains, are evidently beach worn and broken. It is distinctly littoral. Compared with the Lighthouse Point fauna the smaller size,—forms is noticeable. Comparing with the fauna next following the comparative simplicity of the sutures of the Goniatites, like those of *Munsteroceras oweni* rather than those of *Goniatites lyoni* is noticeable. The Goniatites are too fragmentary to lend themselves to reproduction, and the fish teeth and spines hardly characteristic enough.

(5.) **Hardwood Point Zone**, 85 feet below top of Lower Marshall.

Immediately above Flat Rock Point, immediately to the southeast on a 14 foot terrace, and traceable to the water's edge at the southwest corner of Sec. 24, T. 19 N., R. 12 E., we find beds abundantly fossiliferous and easily recognizable. The most striking feature is perhaps the abundance of Solen forms, of which we have hitherto seen only traces, and bryozoa. In the lowest horizon immediately over the Flat Rock sandstone, from which we find previous mention only of a "Cypris like shell* we obtained Fenestella, Sp. 19428, Crinoid buttons," *Soten quadrangularis*, Rhynchonella, traces of Goniatites, *Nuculana*, cf. *Nuculana similis*, Ohio, VII, 17, and about the same size. Cf. *N. beltistriata?* or *N. diversa* or some form markedly produced at rear. We find above some blue not so fossiliferous micaceous shales with even here bits of rushes, and Goniatites, faintly impressed, and borings or burrows of mollusks like Nucula or Nuculana, Sp. 19132, and Sp. 19032. A little higher at Hardwood Point we find a calcareous band rich in fossils, from which Winchell enumerates:

ORTHOCERAS INDIANENSE, Hall Cf. Am. J. S., Vol. XXXIII, p. 354. Cf. *O. cinctum* or *O. goldfussaneum*. Winchell's description is as follows:

"Septate portion of shell more than 3.75 inches in length; inclination of sides forming an apical angle which varies in different specimens from 6° to 11°; transverse section circular; septa at right angles with the central siphon; ratio of depth of chamber to its diameter, in different specimens 2-0, 2.67, 2.71 and 3.46; ratio of concavity of septum to its diameter 2.81; ratio of diameter of siphon to diameter of shell 5.67. No surface marks discernible on the cast.

"Localities. The most abundant Orthoceras in the Marshall sandstone. I have specimens from Marshall, Calhoun county, Holland, Ottawa county, Moscow and various other points in Hillsdale county, and from Hardwood Point (one mile S. W. of Point au Pain Sucre) on the shore of Saginaw Bay in Huron county.

"The specimens from Michigan exhibit all the characters published of *O. Indianensis* Hall, except the apertural constriction, with reference to which I have not been able to make any observations. The casts of these species cannot be distinguished from those of *O. cinctum* Sowerby, as defined by de Koninck ("Animaux Fossiles," p. 513, Pl. XLIII, Fig. 6; XLIV, 5; XLVIII, 3). It is equally indistinguishable from *O. Goldfussanum* de Kon. (pp. cit., 510; Pl. XLIII, 3, 4), except that the septa of this species are separated by only one-eighth of their diameter."

*Winchell's report, 1860; p. 80.

ORTHOCERAS CLINOCAMERATUM, Win.; in Am. J. Sci., XXXIII, p. 356 described as follows:

"The only specimen of this quite distinct form is only 11/2 inches in length, partly septate. It is a fragment of a shell about 3.3 inches long, having a major apical angle of 11°. The section is elliptical, with the minor axis to the major as .24: .45 = 1.88. The first two septa are .08 apart, and the relation of this interval to the larger diameter at the same point is 6.25. The septa are deeply concave, oblique, and slightly sinuous, having one side .12 in. in advance of the other. The greater diameter of the specimen is .7 in. at one end and .45 in. at the other.

"Locality. In the Marshall sandstone at Hardwood Point, one mile S. W. of Point au Pain Sucre, [Called also Flat Rock Point] on the shore of Saginaw Bay."

Compare our specimens 19143, and 19011, 19136, 18118; the forms of Orthoceras seem to be on an average a little smaller than those below.

Cyrtoceras tesselatum, doubtfully mentioned from a small fragment.

GONIATITES MARSHALLENSIS, Am. J. S. Win., Vol. XXXIII, p. 362, described as follows:

"Shell rather long, consisting of at least four whorls, the inner moderately impressed into the outer; transverse section varying from an ellipse of small excentricity to an oblong figure, surface smooth. Aperture and outer chamber not seen. Septa close, the lobes also reaching the next posterior saddles. Dorsal lobe twice as long as its greatest width, clavate, with a long cuspidate acumination, at the extremity of which can sometimes be seen the outline of the minute siphon; first and second lateral lobes similar to the dorsal in form, but successively a little smaller and not acuminate; accessory lobe obtuse, half the size of the second lateral; ventral lobe profound. Dorsal and lateral saddles of form similar to the principal lobes, but regularly rounded at the extremity; first accessory saddle, half the size, the second, imperfectly developed.

"Diameter of largest specimen seen 1.75 (100); major axis of transverse section .59 (34); minor axis .47 (27); length of dorsal lobe .26 (15), of which the cusp is about .07 (4); greatest breadth .12 (7). Diameter of siphon .015 (0.9).

"Localities. The most abundant Goniatite in the feebly cemented, ferruginous sandstone at Marshall. Found also in a similar rock at Moscow, and numerous other localities in Hillsdale and Jackson counties. It occurs in the hard bluish calcareous sandstone at Battle Creek and in the hard purple sandstone at Hardwood Point, Saginaw Bay.

"This Goniatite belongs to the group which embraces *G. Henslowi* Sow, *G. serpentinus*, *cyclolobus* and *mixolobus* of Phillips, but after careful study it seems sufficiently distinct from all. Its closest European analogue is *G. mixolobus* Phil., from the Mountain limestone of the Isle of Wight and the "Posidonomyenschiefer" of Wiesbaden. Its nearest American analogue seems to be *G. Lyoni* Meek and Worthen, (Proc. Acad. Nat. Sci. Phil., Oct., 1860), with which Prof. Hall's *G. Hyas* is identical (See 13th Rep. Regents N. Y., p. 102). The Michigan species, however, differs from the Rockford one in the addition of an accessory lobe and saddle, and in the dorsal lobe being broader and relatively longer. It is also somewhat more involute."

Our specimens, Sp. 19113, 19011, 19137 have a suture much like *Goniatites lyoni*, but with one denticle on a number of the lobes, i. e., an approximation to Ceratites. This is not clearly indicated in Winchell's description but is shown in his specimens and drawings. To these forms we add from the 1860 report, p. 80, Nucula, which Rominger says is *Nucula hubbardi*, i. e.,

Palœneilo sulcatina, Proc. Acad. Nat. Sci. Phil., 1862, p. 418 and 1865, p. 128. Sp. 19011; Sp. 19140 shows muscle scar and pallial line, slightly sinuate. This has been frequently figured, by Conrad, Hall and Herrick.

Solen quadrangularis, Win. Proc. Nat. Sci., 1862, p. 422, an abundant and characteristic form often in purple micaceous shales. Sp. 19010, 19028, 19136.

(*Clymenia?* Cf. pp. 85 and 86). As no Clymeniæ are returned from the Marshall in Winchell's final list, he undoubtedly concluded to refer the forms in question to the Goniatites.

Beside the forms mentioned by Winchell, Rominger adds *Rhynchonella* and *Productus*. We may add a variety of fish remains, to wit: Sp. 19011, 19023 shark spines in considerable variety, cf. Acanthaspis;

Fish teeth; as in the grindstone beds there are often small black rounded fish teeth, but occasionally we have something better, e. g. *Cladodus* (*concinnus?*) Sp. 19139, very well preserved, one large, four small cusps, two on each side, the outer larger.

Psammodus or cf. *cochliodus*, a large pavement tooth, Sp. 19133 *Ganoid* scales, Sp. 19027.

Conularia, Sp. 19109, cf. 19146, a mere fragment.

NUCULITES FALLAX, n. sp. Cooper, Plate XI, Fig. 4. Sp. 19259.

Shell, small, elongate, ovate, width equal to three-eighths the greatest length of the shell, cardinal and ventral line equidistant for the greatest length of the shell, anterior end truncate, posterior portion of the shell meeting the ventral margin at the end of the umbonal ridge where it is abruptly rounded; beak depressed anteriorly, about one-tenth distant from the end of the shell, clavicle extending ventrally marked with imperfectly preserved concentric markings. Teeth not shown in any specimen yet found.

Formation and Locality.—In the lower Marshall along the shoreline just west of Port Austin, Huron County.

SANGUINOLITES MICHIGANENSIS, Herrick. Figured here Plate XI, Figs. 12, 13, Sp. 19283, 19284.

1888. *Sanguinolites Michiganensis*, Herrick or Winchell. Bull. Denison Univ., Ohio, Vol. Ill, p. 70, Pl. 7, Fig. 10.

Shell quadrangular, ovate, dorsal and ventral lines subparallel, posterior end slightly large. Beaks one-fourth distant from the anterior end, slightly appressed, not projecting beyond the hinge line. Umbonal ridge well defined, extending to the abruptly rounded posterior ventral margin. Umbonal slope slightly concave dorsally, having a well defined depression extending from the middle of the ventral margin towards the beak. Anterior end abruptly rounded, with a well marked lunule on the dorsal part. This species was identified by Alexander Winchell at the time the Ohio specimens were being studied as his *S. Michiganensis*, but no description or figure from him is extant. The species was figured by Prof. C. L. Herrick without any definition.

"Formation and Locality. From the Marshall or upper Waverly immediately west of Port Austin."

SANGUINOLITES BOREALIS? Winchell. (Plate XI, Fig. 11, Sp. 19282.)

1862. *Sanguinolites borealis*. Winchell, Proc. Acad. Nat. Sci., Philadelphia, p. 415.

"'Shell rather small, ventricose, transversely elliptic; beak somewhat projecting and incurved, less than one-fifth the shell length from the anterior extremity, with a lunuliform excavation in front of it; dorsal margin straight; ventral margin slightly arcuate; posterior extremity regularly rounded; anterior sharply bent in front of the lunule, from which it slopes with a truncate backward curve to the ventral border; umbonal slope extending diagonally to the infero-posterior margin, somewhat angulated behind the beak, and inflected toward the cardinal region. Surface of shell of northern specimens unknown; cast showing several distinct concentric grooves. Shell of southern specimens thin, marked both with concentric and minute radiating striae. Greatest height of shell along the perpendicular from the beak; greatest convexity in the middle of the same line.

"Length (in inches) 1.10 (100); breadth .44 (40); thickness of right valve .15 (44)."

"Locality. Grindstone quarries, Pt. aux Barques above the gritstones and Moscow, Hillsdale county. The specimen here illustrated is from Hardwood Point, Huron county, Michigan, where it was found in red, friable, ferruginous sandstone."

Michigan Geological Survey Collection, number 19282.

Leaving Hardwood Point and going southeast after passing a relatively massive sandstone we come to a fossiliferous shingle, and on the bluff of the Algonquin terrace, which the Port Austin-Port Crescent road skirts, we find rock exposed, only certain narrow belts being fossiliferous; similar beds occur on Sec. 2, and on the hill of Sec. 31 adjacent, with fauna so much alike as to make them essentially one horizon. Sp. 19112-19128, 19140-19143, 19145, 19279.

From them we have:

Ganoid scales, rhomboid diagonally wrinkled, Sp. 19117.

Ganiatites marshallensis, as mentioned; also Sp. 19117, 19113, 19128,

Goniatites allei? Sp. 19142, 19113, 19126, 19127, 19140, a fragment.

Orthoceras indianense or *multicinctum?*, 19118, Sp. 19143.

Fenestella, Sp. 19121.

Bellerophon, cf. *B. nautiloides* or *B. galericulatus*; Sp. 19113, 19140, 19141.

Characteristic of these beds in a wealth of lamellibranchs, especially pterinoid forms, inclined, with a straight hinge line, e. g., *Leiopteria torreyi* cf. *ortoni*, Ohio, VII, Pl. XXIV, Figs. 1, 8, 9,10, 11, 12. If recognized by Winchell it was probably as a Pterinea or as *Myalina Pterinaeformis*. The forms are about the size of Herrick's Fig. 10; cf. *Anthracoptera elongata* Q. J. G. S., 1893, XLIX, Pl. VII, Fig. 16. Sp. 19114, 19127, 19128, 19145.

LEIOPTERIA TORREYI? Hall. (Plate XI, Fig. 2).

1884. Hall. Pal. New York, Vol. V, Part I, Pl. I., p. 174.

This species which is described by James Hall from the sandstone and conglomerate of the Chemung group at Panama, N. Y., is defined as follows:

"Shell of medium size, rhomboidal, sub-falcate; body narrow ovate, arcuate, oblique at an angle of less than 45° with the hinge, height equal to about; two-thirds of the length; anterior and basal margins broadly curving from the byssal sinus; post basal margin produced and abruptly recurved.

"Left valve very convex, gibbous in the middle and above. Eight valve unknown.

"Hinge line straight, about equal to the height of the valve. Beak sub-anterior, directed forward, acute, prominent and arching over the hinge. Umbonal region narrow, ventricose, well-defined, subtending an acute angle.

"Ear large, bending downward, marked by a strong oblique fold, limited by a broad, vertical byssal depression and shallow sinus margin convex; extremity apparently obtuse. Wing joining the body above the posterior extremity, limited by the nearly verticle post-umbonal slope which makes a more or less marked sulcus; margin concave; extremity produced, acute.

"Surface marked by a fine striæ of growth which are somewhat regularly lamellose on the body of the valve.

"A left valve has a length of 29, height 22, hinge line 21."

Formation and Locality. From the Marshall group along the Port Crescent road immediately west of Port Austin, Huron county, Michigan.

Nuculana, cf. bellistriata. Sp. 19125 ill preserved.

Nuculites fallax, as described above.

PALÆONEILO SULCATINA, Sp. 19140, 19141, shows the posterior muscle scar and slightly sinuate pallial line.

Sp. 19145 is concentrically striated and very much like Winchell's forms, *Sanguinolites* (*Cardinia*, *Inoceramus*) concentricus, but traces of ligamental pits on a straight hinge line make the genus much more akin to Inoceramus; cf. also *Sanguinolites amygdalinus*.

The usual state of preservation of these fossils is in yellow fragile casts in a bluish to purplish impure sandy matrix. It will be noticed that the fauna of these upper beds, is (with the exception of some lamellibranchs), practically the same as that of Hardwood Point. Taking the two together they differ unmistakably from the fauna below the Port Austin sandstone by the replacement of brachiopods by lamellibranchs and the more complex sutures of the Goniatites.

From the Lighthouse Point beds to the top of these upper beds is (260 + 176) some 436 feet, with two considerable sandstone belts, perhaps three or four, included. Yet if we compare our fauna with those of Herrick's zones we find that though the Lighthouse Point section seems to correspond decidedly better with the Waverly freestone, than any lower horizon, on the other hand the upper beds also find their nearest analogues in the same stratum. So that either the Waverly freestone corresponds to a much larger series of deposits in Michigan, or the fauna lasted much longer in Michigan, see below p. 288, or two faunas consecutive in Michigan were migrating so as to meet and be contemporaneous in Ohio. In that case we might suggest that the brachiopods, Syringothyris, Rhynchonella, and Spirifer, and Romingerina were moving southwest while the solens and aviculoids came north. The generally smaller character of the upper faunas in Michigan suggests that in some way the conditions were becoming more unfavorable to life, a supposition in entire accordance with the fact that hitherto the out-crops of the Upper Marshall or Napoleon have proved unfossiliferous.* Finally the fauna of Marshall and Battle Creek, seems as already stated by Winchell to correspond to the upper zones of our section.

Ohio correlations

by W. F. Cooper.

The correlation with the Ohio is as follows:†

To Prof. C. L. Herrick, President of the State University, Albuquer-que5 New Mexico, I am especially indebted for favors which have always been extended, and through which this work has been begun.

*See Rominger III, p. 88.

†From this point to the end of the section is solely by W. F. Cooper and expresses his views.

The lower Carboniferous of Michigan, beginning at the bottom, has been separated into the Bedford shale, Berea grit, Berea shale, Coldwater (Cuyahoga in part) shales, lower Marshall sandstones, Napoleon or upper Marshall, Michigan series, and Bayport (Maxville) limestone.

In Ohio the same strata are represented by the Waverly formation, which with some modifications from the reports of Professor C. L. Herrick and Dr. Edward Orton, may be divided into the Bedford shale, Berea grit, Berea shale, Buena Vista flags, Cuyahoga shales, Raccoon shales and sandstones, and conglomerate I; the middle Waverly or lower Logan, conglomerate II; the upper Logan or Burlington and Keokuk and Maxville.

The Bedford shale which forms the lowest member of this series has in southern Michigan a thickness of fifty feet in places, according to the records of the well borings (Geol. Surv. of Mich., Vol. V., Pt. II). In Ohio the horizon extends in its line of outcrop from Pennsylvania west and south as far as the Ohio river, and doubtless beyond into Kentucky. It contains a recurrent fauna with a Hamilton fades. Some of the characteristic New York Hamilton species which are found in Ohio are: *Orthis vanuxemi*, *Chonetes scitulus*, *Ambocoelia umbonata*, *Macrodon hamiltonae* and *Cypricardella bettistriata*. In northwestern Pennsylvania these strata are said to be represented by the Cussewago shales.

In Huron county, Michigan, the Bedford shale is succeeded by the Berea grit, which serves very well as a datum plane as is shown elsewhere in this report. In Ohio the Berea grit varies considerably in thickness, being anywhere from five to one hundred and fifty feet thick. In the upper layers it exhibits a tendency to become flaggy and more fossiliferous. *Atrypa reticularis* and *Leptaena rhomboidalis*, together with several other species of a local fauna, have been found in the flags of Delaware county, Ohio. In Pennsylvania it has been identified with the Corry sandstone. The Berea shale is immediately over the Berea sandstone. In Huron county, Michigan, it is easily traced in the well borings and has an average thickness of 115 feet while in the southern part of the state it is in places only twenty-five feet thick. This horizon which has also been called the Waverly black shale, by Andrews, varies in Ohio from 15 to 50 feet in thickness, throughout the line of outcrop, and is an exceedingly persistent and well defined horizon. In northeastern Ohio; near the Pennsylvania line, it lies immediately under the Carboniferous millstone grit; a fact of importance in the development of the lower Carboniferous of that state, which has heretofore been misunderstood.

Lying upon this horizon are the Buena Vista flags which are deserving of recognition as a horizon separable from the Cuyahoga shales above. The Dictyophyton, Producti, and *Atrypa reticularis*, which are found in them, apparently sustain the same relation to the Chemung of New York as does the Bedford to the Hamilton of that state. They are extensively quarried at Buena Vista on the Ohio river. Northward they extend into the valley of the Cuyahoga river and to the east as far as Warren county, perhaps farther. In Michigan their position has not been determined as yet, but they will probably be found south of Harbor Beach or White Rock along the lake shore.

The Cuyahoga shales vary in lithological character, throughout any one continuous section, but can, within certain limits, be distinguished by a dark blue nodular shale which very often contains fossils exquisitely preserved. These fossils may be found at Cold-water in Branch county and in less limited numbers at Rock Falls near Harbor Beach, Huron county, along the lake shore. The same nodules are found forty feet below the Carboniferous conglomerate at Cuyahoga falls, at Moot's run in Licking county nearly 225 feet below the same horizon, and at the level of the Ohio river at Sciotoville nearly 200 feet below the coal measures. There are sections in Warren county, Ohio, where this horizon is absent. Judging from the gradually extending shore line southward on which the later zones in part were deposited it is probable that the elevation of the strata had then begun in Warren county before the deposition of these beds.

This zone which is embraced in the Coldwater series of Michigan is 200 feet thick more or less in the southern part of the state. In Huron county it is difficult to draw the line between the horizons below and above these strata. The top of the beds outcropping near Harbor Beach must be about 1200 feet below the Coal Measures, while the top of the Berea shale is given by Dr. Lane from the well records as 500 feet lower at that locality which measures the approximate thickness of the zone. I think it probable, however, that a portion of the lower part of these strata may be included in the Buena Vista horizon. There is south of Harbor Beach at the mouth of Allen creek a section at Rock Falls where I collected *Chonetes scitulus*, *Productus shumardianus*, *Productus newberryi*, var. *annosus*, *Streblopteria media*, *Conularia gracilis*, and *Phaethonides spinosus*.

These forms are also found in the Cuyahoga in Ohio. Lithologically and palæontologically this outcrop is more closely paralleled by the exposures which occur in Licking county than in the northern portion of the state in the valley of the Cuyahoga river. There is cumulative evidence to indicate that the strata of this zone were laid down in a basin rather limited to the eastward in central Ohio; which existed before the Cincinnati anticline had developed, and which may have obtained its sediment from the northward. At Moot's run, Licking county the Cuyahoga is represented by a series of light blue flags containing concretions and a *Chonetes scitulus* in the greatest numbers, which are overlain by a shale which contains nodules often with perfectly preserved fossils. The section at Rock Falls is identical in character, superposition and habitat which can hardly be accidental when taken in connection with its relative position. The same strata at Coldwater I have not yet had an opportunity to study fully.

The Waverly shale, which is a term Professor C. L. Herrick has given to the upper 40 or 50 feet of the lower Waverly or division I is rather apt to be confusing as thus limited. I have adopted the name Raccoon shales which was earlier used by L. E. Hicks to include all the strata between the middle Waverly or Lower Logon and the Ohio black shale, for this particular zone, which is the uppermost part of his series. A typical outcrop is found on Raccoon creek half way between Granville and Newark, Ohio, where no less than thirty species have been collected, most of which are confined to these beds. Over two-thirds of the number are lamellibranchs. Some of the characteristic species are: *Palæneilo concentrica*, *P. attenuata*, *Sanguinolites flavius*, and *Sanguinolites unioniformis*. North of Licking county this formation thins out about half way between Wooster and Lodi, Ohio. In Michigan I have been unable to correlate it in, Huron county, but stratigraphically and lithologically it corresponds to the 196 feet of strata outcropping below the conglomerate at Point aux Barques lighthouse and southward almost to Harbor Beach. In Hillsdale county and at Verona mills near Battle Creek the same layers are apparently represented by a coarse grained, yellowish, somewhat friable sandstone which contains in great abundance *Palæneilo concentrica* and *P. attenuata.* At Waverly junction, near Holland in Ottawa county, the same strata are extensively quarried. At that place over 35 feet of rock are exposed which is abundantly fossiliferous, almost all the species being lamellibranchs. *Sanguinolites flavius*, *Palæoneilo concentrica*, *P. attenuate*, *Nucula iowaensis*, *Nuculana similis*, *Athyris lamellosa*, and *Bellerophon galericulatus* were the only species identified which are characteristic of the Raccoon shales in the Ohio basin. The almost entire absence of brachiopods rather tends to emphasize the relationship, but the cephalopods are relatively much more abundant than in Ohio.

We have, separating the lower Waverly from the middle Waverly or lower Logon, a band of conglomerate which varies considerably in thickness and which extends in variously modified phases from southern Ohio to Point aux Barques lighthouse. In Licking county it is well exposed in the bed of a small "run," in a quarry about one mile south of Newark, Ohio; at the "dug way" three miles west of Newark; and at Wooster, Ohio, immediately north of the city on Christmas run; and on the shore of Lake Huron at Point aux Barques lighthouse. (See fig. 5.) It is not found in the valley of the Cuyahoga river which was elevated before the formation of this bed. In otherwise continuous .sections north of Wooster and south of Burbank the Cuyahoga shale lies immediately underneath conglomerate. I. In this connection it may be well to notice the observation of A. C. Lane that in the conglomerate at Point aux Barques lighthouse rounded pebbles of a black shale were found which could hardly have come elsewhere than from the Devonian black shale. The deposition of this bed must have been a time of important geologic action. In Ohio nearly all of the species became extinct as the result of the change of environment, and but few forms are found in the horizon in question, so that its correlation rests to a large extent on stratigraphical and faunal relations. For in the underlying shales and sandstones the fauna is largely lamellibranch, almost entirely so in point of numbers; in the conglomerate it consists altogether of brachiopods. *Spirifer deltoidens* is one of these characteristic species which occurs in Ohio and in Michigan along with several peculiar brachiopod species which are not found in the Ohio basin. There is evidence to indicate that this bed was in Ohio deposited by river action coming from the north or north-westward.

The lower Logan or middle Waverly, the "quarry rock" of Central Ohio, is represented in sections from the Ohio river to Burbank; in Michigan from the Point aux Barques lighthouse to the *Romingerina julia* stratum west of Grindstone City. In the southern and central part of Ohio it is 40 feet in thickness on the average, while in a quarry northwest of Wooster it is 60 feet thick. In Michigan the series which is in part a representative of the Marshall exposed in Calhoun county and the upper Kalamazoo valley is made up of grits, sandstones, conglomerates and shales with an abundant fauna. The thickness of this division which should be made to extend from the Point aux Barques lighthouse to the *Romingerina julia* layer west of Grindstone City, and perhaps the 20 feet of strata resting upon it, is approximately 215 feet in thickness and includes the lower 40 feet or so of the Marshall as defined by Winchell. At Point aux Barques lighthouse the horizon is 935 feet and more below the Bayport or Maxville limestone as exposed on Wild Fowl Bay northeast of Bay City. Within this greatly increased thickness of sedimentation there are at least four horizons each with their characteristic fauna.

Thirty or forty feet below the top of the series as it has here been limited we have a layer which outcrops along the roadside leading to Port Austin, and on the old lake shore line west of Grindstone City. In it occur *Romingerina julia* and *Camarotœchia camerifera* in the greatest abundance, in places making up the entire stratum. On Sec. 17 in the valley of the Willow river the layer again outcrops. At this locality the specimens are better preserved, while *Romingerina julia* is relatively more abundant. These species are distinctive of the lower Logan in central Ohio, and while it is impossible to demonstrate the same relationship here, there is evidence when taken in conjunction with the underlying beds that they form an integral part of this series and of the middle Waverly in general. About 15 feet below are the fine grained and uniform blue grits which make the famous Huron county grindstones. In and near these grits occur a great variety of fossils, especially of cephalopods which afford little data for comparison. Some of the species which are found there and admit of identification in the "quarry rocks" of central Ohio, are: *Syringothyris carteri*, *Edmondia burlingtonensis* and *Goniatites lyoni*. Incidentally it might be observed that these species are considered by some authors as characteristic of the Kinderhook beds of Illinois. The lower bed of "peanut conglomerate" exposed just west of the gristmill at Grindstone City is characteristically full of *Nuculana bellistriata*, a form which has not yet been found in Ohio. If we continue along the coast to Point aux Barques lighthouse we find overlying the conglomerate, streaks of sandstone imbedded in the shale and filled with a great variety of fossils, from which both Rominger and Winchell have mentioned many species, and which will undoubtedly yield more material to any one who will take the pains to work them up. From this bed we have collected many species which are more distinctly Carboniferous in character than those from the Cuyahoga strata farther south. Lithologically the formation both here and in the valley of Willow River is typically lower Logan, faunally the species which are here given may be considered typical of the same horizon along with some species which have not yet been identified in Ohio. Of the former we have identified the following forms: *Syringothyris carteri*, *Camarotœchia sageriana*, *Cryptonella eudora*, *Crenipecten winchelli*,? *Sanguinolites naiadiformis*, *Schizodus triangularis*, *Bellerophon cyrtolites*, *Pleurotomaria strigellatta* and *Proetus missouriensis*. To these characteristic species may be added *Derbya crassa*, *Spirifer centronatus*. *Spirifer huronensis*, *Eumetria polypleura*, *Palæoneilo marshallensis, Leiopteria halli ?* and many other forms which are in part generally distributed throughout the lower Carboniferous in Ohio, along with others not yet found in that region.

Extending from the beds at Flat Rock Point west of Port Austin to the heavy bedded dark sandy flags overlying the *Romingerina julia* layer west of Grindstone City we have 110 feet of strata which are almost barren of fossil remains. These layers which are embraced in the lower Marshall have their base 200 feet below the top of the lower Marshall and 40 feet or less above the *Romingerina julia* zone. I have placed the base at this point only on account of the negative evidence afforded by the almost entire absence of organic remains, together with the physical and geographical changes which occurred at the time of the deposition of its beds.

The base of this series consists of flags succeeded by about eighteen feet of massive white sandstone at Point aux Barques hotel. Above this strata for about sixty-five feet are soft, greenish, slightly micaceous, then bedded slaty or sandy blocks rather insufficiently exposed in which the only fossil found was a species of Conularia too poorly preserved for identification, but which may be the species described in Ohio as *Conularia newberryi*. This series of strata affords a problem that it is not yet possible to explain. Stratigraphically it may be relatively represented in part by conglomerate II in Ohio which separates the lower and upper Logan, and I am inclined to believe that this may be proven true. Conglomerate II does not extend as far south as the Ohio river. In Ashland county southeast of Mansfield it varies in within a distance of two miles from 3 to 20 feet in thickness. At Wooster, Ohio, it is very nearly one foot thick, while northwest of that place it is 15 feet in thickness. Going directly east from there it is not represented in the valley of the Kilbourn river where the strata afford an otherwise continuous section. It is largely problematic to attempt to bridge over the hiatus from this point to the outcrops in Huron county, but as in the case of the overlying and underlying beds, I think that it will prove true, that the sediments which make up in part at least the remnant of strata which are in the Ohio basin will be shown to have come from the northwest and that these barren strata above mentioned are partially represented by the bed of conglomerate which was deposited at the close of the lower Logan, in Ohio.

Above these unfossiliferous beds there is an abundant fauna, which is the typical Marshall according to Winchell and in all probability is represented by the lower beds of the upper Logan in central and southern Ohio. These species are smaller than in the fossiliferous beds at Grindstone City, indicating somewhat more unfavorable conditions for life quite in harmony with the series of unfossiliferous beds below and above as A. C. Lane says: "The sutures of the Goniatites are more complex than they are below, and there are several species of lamellibranchs, especially aviculoid and solenoid forms and a scarcity of brachiopods." This gives the fauna a fades considerably resembling that over Conglomerate II at Newark, Ohio. This series comes down some eighty-five feet or less below the upper Marshall. The only species identified thus far with the Ohio species from approximately the same horizon are *Ctenodonta hubbardi*, *Grammysia hannibalensis*, *Prothyris meeki*, and *Solen quadrangularis*. In other parts of the state this last species is quite generally distributed. There also occur in the same beds *Nuculana similis*, *Myalina michiganensis*, *Sanguinolites amygdalinus*, *Goniatites lyoni?* and several other forms which do not afford any data for correlation. In a general way these beds of the lower Marshall conform stratigraphically and palæontologically to the upper Logan, and in the absence of any definite data they might be provisionally regarded as forming a part of that series.

Immediately above this series of strata we have about 300 feet of sandstone which is exposed in the Babbitt quarry near Little Oak Point, at Hat Point, and various places near Tyre, but has proven unfossiliferous. These beds form the Napoleon formation of Winchell, and are succeeded by the beds of the Michigan (Salt Group) Series having a thickness of almost two hundred feet and containing gypsum, which indicates that it was laid down in a body of water largely shut off. It is possible, as Mr. Lane suggests, that this occurred at the time the upper Logan was being deposited in central and southern Ohio, when the strata in the north part of Ohio were above water, until the time of the formation of the Carboniferous millstone grit and thus occupies the gap in the geological column in northern Ohio.

The Grand Rapids or Bayport limestone is extensively quarried in the Grand Rapids and Bayport quarries. It seems to mark without doubt the culmination of the depression during which the sea extended quite far north not long before the deposition of the Coal Measures. In Muskingum county, Ohio, these beds are twenty-five feet thick, while in Licking county a few miles further north they are absent, besides a considerable portion of the upper Logan. However, in the lowest coal measure conglomerate eight miles northeast of Newark, Ohio, a large number of fragments of limestone were broken out which contained a few fossils which can only be referred to the age of the St. Louis or Kaskaskia. These conglomerates are also full of impressions of Lepidodendron and Calamites. The quartz and igneous material are rounded as though transported from a distance. The fragments of limestone, however, are angular and badly decomposed which indicates that they were eroded and carried from no considerable distance, certainly from a source nearer than that which furnished the mass of the rock. We have here then, apparently, an explanation of the gap which exists above the highest formation of the lower Carboniferous in northern Ohio, and incidentally of the hiatus which is found in the upper horizons of the different basins in Ohio and Pennsylvania. This correlation is based upon the following species: *Lithostrotion canadense*, *Spirifer glaber*, *Athyris subtilita*, *Allorisma clavata*, *Allorisma elongata*, *Schizodus chesterensis*, *Bellerophon sublævis*, and *Phillipsia longispina*.

The correlations which have here been stated may be modified, but in so far as they relate to Huron county I do not think that any modification will materially alter the relationship. It is reserved for a future time to determine how far the same sequence holds good for the other parts of the state.

Newberry Library, Chicago, Illinois, April 1, 1898.

§ 4. Fossils of the Soule and Bayport limestones.

As we have said the outcrops of the Napoleon sandstones, whether at Hat Point, the Babbitt sandstone quarries, or at any other of the exposures have not yet yielded fossils.

(a). **Soule and Oak Point, Michigan series.***

The Michigan series has also proved sparingly fossiliferous to our researches, but Rominger seems to have been more successful.

Around Oak Point on Sec. 18, T. 18, R. 11, he gives the following list, p. 103.

Productus ventral valve very convex, shallow, sinuated in the median line, and covered by from 40 to 50 sub-equal ribs.

Retzia, like *R. vera*, i. e. *Eumetria marrcyi*.

Terebratula like *Cryptonella eudora* (generic reference doubtful).

Spirifer (*marionensis*)?

Spiriferina (*spinosa*).

All these specific identifications are very doubtful and the specimens in loose fragments not absolutely in place; crinoids, bryozoa, brachiopods, and bivalves were well represented.

In dredging Caseville Harbor rounded strongly driftworn boulders, of similar lithological character enclosing similar fossils are found, and among them are dark bluish colored fine grained rocks crowded with shells of Myalina, Modiolopsis, Schizodus, with some Rhynchonella, Terebratula, Retzia, etc., intermingled. These may very likely be from sublacustrine outcrops of the Marshall. Winchell found no fossils.

The Productus seems to be near *Productus arcuatus* (Sp. 19009) though our one specimen is badly crushed. One specimen of Spirifer with five striations in the sinus, appears to be *Spirifer forbesi*, the hinge line being quite long. We doubt Rominger's identification of *Sp. marionensis*, and probably he only intended to express general resemblance. Quite likely there are other Spirifers present, but all seem to have a striated sinus. The investigations indicate a brachiopodous fauna quite in contrast with that of the Marshall, though apparently most of the specimens come from near the lower part of the series, say the lowest hundred feet.

Geo. H. Girty has found Nautilus, Lituites, Orthoceras, *Spiriferina kentuckyensis* (?), *Productus rushvillensis* (?), Rhynchonella, Derbya and plant remains.

The fauna certainly is not inconsistent with the Augusta (Burlington-Keokuk) group; lithologically it is most allied with the Keokuk. Both Rominger and Winchell assume a closer affiliation of this group with the Bayport rocks than is warranted as it seems to me. Not only is there the difference already described, in lithological character and character of well water, but also a different fauna, so far as I can judge. I have seen fossils from this group in the quarries at Alabaster, Iosco county, and studies in that county will doubtless throw more light upon the subject.

*See pp. 12 to 16, 103 to 113.

(b). **(Bayport) Maxville limestones.** (200-247 feet above the top of the Napoleon sandstone.) The general equivalent of the outcrops around Bayport, and the islands off the shore, and the outcrops around the Shebeon, and the Charity islands has been remarked by all observers. Under the Lithostrotion beds, are certainly the more compact beds with chert nodules and Syringopora, Allorisma and Productus.

The following table shows the fauna so far as it has been determined. In the first column is given the names of the fossil forms. There is undoubtedly a great deal of synonymy, and probable synonyms so far as the names have been applied to forms in this limestone are grouped together. Identifications which I strongly question are bracketed. In the following columns I have given reference to the author who has mentioned the form in the present connection, and also given the numbers of the Survey specimens, which appear to contain the given form, indicating 19000 by '000, etc. In some cases the numbers and references may not refer to exactly the same but only a similar species, as is more fully explained in the foot notes. I have divided the references into four columns. The first contains all references to the exposures at Bayport, including also the islands of Wild Fowl Bay; the second includes all the references to the Charity islands. The third includes all references to the Shebeon locations, and the last contains references to other places, particularly to Grand Rapids, and to the Maxville limestone outcrops of Ohio.

The palæontological evidence thus accumulated as to the age of these limestones is quite satisfactory. Winchell at first was inclined to think that the limestones in question might include attenuated representatives of the Mississippi limestones from the "geode bed," i. e., upper Augusta up into the Kaskaskia, and in Walling's Atlas he considers that the St. Louis and part of the Keokuk are represented, from the presence of *Lithostrotion canadense* and *Spirifera keokuk*. Rominger does not attempt to assign the horizon closely. Dr. C. H. Gordon visited the Shebeon localities at my request, and from a brief observation, was inclined to place them as Upper Lower Carboniferous, at least as high as the Saint Louis. Whitfield refers the equivalent Maxville limestones of Ohio, to the Saint Louis-Chester groups. Thus there is a prima facie case that the limestones belong in part at least to the St. Louis. But when we come to study the affinities closely, it seems to me that the affinities are more strongly with the Kaskaskia—(Chester) than with the Keokuk. *Allorisma clavata*, *Zaphrentis spinulosa*, *Athyris sublamellosa*, *Spirifera glaber*, v. *contractus*, *Terebratula sub-retziæformis*, and the form which Winchell took for *Spirifer keokuk*, which I think to be near *Spiriferina spinosa*, all point that way, thus agreeing in placing it close to the dividing line between the St. Louis and the Kaskaskia. But the highly characteristic Lithostrotia, *L. canadense* and *L. proliferum* and numerous other forms closely like those in the Saint Louis, viz., *Productus altonensis*, *Athyris trinucleus*, *Bellerophon sub-lævis*, together with the fact that it must mark an era of continental depression seem to make it nearly coeval with the top of the Saint Louis, even though the fauna has as strong or stronger affinities with the Kaskaskia. One might be tempted to separate off the Shebeon outcrop with *Zaphrentis*, and *Spiriferina spinosa* and refer them alone to the Kaskaskia, but the Spiriferina is not atypical *S. spinosa*, but is almost certainly the form referred to by Winchell as *Spirifer keokuk* and occurs associated with a form exceedingly like *A. trinucleus* and a Phillipsia. Moreover we are not sure that the Shebeon specimens are above those of Bayport, but even if they are, there is not more than fifty feet or so in the section. Winchell's general idea seems to be very nearly right, except that the horizon is a little higher than he supposed.

The Lithostrotia are illustrated by Rominger in Vol. III. Pl. LV. The remaining forms must await a closer study of the Kent Scientific Institute, Strong's and the Winchell collection before they can be gone into more thoroughly, and that will be the time to illustrate them.

The fragments of vegetation as yet discovered from the Sebewaing Coal, mines do not deserve an elaborate description. Ferns are notably absent, rushes, stems and Stigmaria, are the commoner forms.

References are indicated for the first column thus: R = Vol. III of our reports on p. 120; W. = Winchell's lists given in the 1860 report, pp. 100, 103-110: Our specimens, from 19000-19008 are from the quarries; Sps. 19170 — 19173 from 725 paces N., 2000 W. in Sec. 36, T. 17 N., R. 9 E.; Sps. 19206 — 19207 from the shore of Wild Fowl Bay; Sps. 19208 — 19219 are from North Island. St. I refers to Stone Island.

For the second column the references are: G. W., list from Charity island by Winchell, 1860 report, pp. 101-110; L. W. list from little Charity, same reference; R. Rominger's list, p. 119; our numbers may be compared with the description of the locality in Chapter V, § 4. For the Shebeon (Cheboyong) W: refers to Winchell's list, 1860 report, pp. 100-113; and possibly some of the forms of Rominger's Bayport list come from the Shebeon.

In the last column M. refers to fossils from the Maxville limestone of Ohio, described by Whitfield, in Vol. VII, of the Ohio reports.

G. R. S. refers to fossils collected by Strong at Grand Rapids, and described in No. 3 of the Proceedings of the Kent Scientific Institute.

No. 8 of these proceedings I have not yet seen.

G. R. W. refers to Winchell's lists from Grand Rapids, 1860 report, pp. 103-110.

Wh. refers to lists of fossils from Grand Rapids, given in a paper by Mr. C. A. Whittemore before the Michigan Academy of Science in December, 1895, (First Report, p. 63), or furnished in MSS by him from the labels of the Kent Scientific Institute Collection. There are a number of other lists given by Rominger at various pages and cited by R. with reference to the page number (111 to 119).

	Locations near Bayport.	Great and Little Charity Islands.	Locations near the Shebeon.	Other locations.
Brachiopoda				
Productus altonenis				G.R.Win.
(4) *Productus pileiformis*, cf. *Productus cora*				Mich. Win. M.
Productus (elegans) cestriensis cf. fasciculatus	.006			? M.
Productus fasciculatus? *Wh.*	N. I '199			
Productus (Wilberanus) nebraskaensis				?
Productus (delicate) too finely striated for *P. elegans*, too coarse for *P. pileiformis*		182	246, '247	
P. sanctatus	St. I			Wh. 3 sp.
Productus (unstriated ? *punctatus ?*)	Girty.			G R Win.
Productus ?	R. .006	'176 '183 R.		G.R.Win. R. R. 118,113,116
Productus flemmingii burlingtonensis		upper beds		Wh.
Streptorhynchus crassum, cf. *Irthis lasellensis* (cf. *Hemipronites crassum*) = *Derbya crassa*			'251	
Orthis umbraculum ? & *O. robusta* with *Phillipsia longispina* cf. *Streptorhynchus umbraculum*		'183		G. R. Win.
Orthis ?	St. I			G. R. Win.
Athyris subquadrata or *trinucleus*	N. 1	'199	'246	G. R. Win.
cf. *T. ambigua*	'192	'192		W. L.
= *Seminula quadrata*		'197		
Athyris sublamellosa		'202		
Athyris ?		'181?		G. R. Win.
Athyris = Cleiothyris roissyi				G. R. Win.
Eumetria vera, concentrica		'249		Pt. AuGres.
Spirifera, (*Martinia*) *glaber*, var. *contractus*		'249		M.
Compare Terebratula rhomboidea, and *roysii*				
Terebratula sacculus or turgida				G. R. Win.
= *Dielasma sacculum*				M.
Terebratula subretziaeformis				G. R. W.
cf. *Seminula argentea*				
Terebratula	St. I. Win.			

		Locations near Bayport.	Great and Little Charity Islands.	Locations near the Shebeon.	Other locations.
	Atrypa				Pt. Au Gres. Wh. G. R. S.
(6)	*Spirifer rockymontana*, cf. *opima* and *Keokuk?*) Wh.	'173	'7–'37	'246	M.
	Spirifer keokuk v. *Halli*, cf. *Spiriferina spinosa and kentuckyensis*				G. R. Win. Wh.
(1)	*Lithostrotion* (*mammillare=canadense*)	R. '003			G. R. W. L.
	Lithostrotion (*longiconicum ? = proliferum*)	Girty N. I '217	G. W. '178 '197'180'208	R. 112	G. R. R.
	[*Cyathophyllum fungites, vermiculare.*]	R. '001,'110 '208, 212	R. upper '183		G. R.
	Cyathophyllum? More expanded and irregular		Win.		
	Caryophyllia duplicata		Win.		
	Acervularia ?	Girty ? Girty			
	Syringopora ramulosa ?	Win. R. '005	G. W. & L. W. '175 R. up'r. 207		Pt. Au Gres Win. Pt. Au Gres, R. 118.
	Zaphrentis cliffordana, Wh.	Girty		'254	M.
	Z. spinulosa	R.	R. Pl. L. V.		R. 118, 113, G. R.
	Z. spinulifera				Wh.
	Archæocidaris				Grand R.
	Cyathocrinus maxvillensis, Wh.				M.
	Crinoid stems, 2 or more species	'006		'246–'250	R. 114. G. R. R.
	Pentremites elegans				M.
(2)	Bryozoa	R.	N. I '193 '201 '217	'243 '244 '249	G. R. Win. Wh. R. 118. R. 113.
	Fenestella membranacea	'170	two spec.		G. R Win.
	Fenestella sp.?				M. R. 111.
	Trematopora		R.		R. 113. Gr. R. R. 111
	Polypora (cf. *shumardii?*)	R.	R.		Gr. R. Win.
	Polypora varsoviensis? Wh.				M.
	Cladopora ? sp				G. R. Win.
	Cladopora ?		G. W.		
	Coscinium ?		G. W.		
	Monticulipora ? (Rhinopora)				G. R. Win.
	Ptilodictya ? (Stictopora)				G. R. Win.
	Synocladia rectisiyla				
	Stylinia astraeiformis				
	Diphiphyllum constrictum				
(3)	Chert nodules	'002 N. I 211 212	'172	179	

		Bayport.	Charity.	Shebeon.	
	Pinna maxvillensis				M.
(7)	*Allorisma subcuneata, concentrica* or *andrewsi*, Wh.	Girty. '000	'189		M. M.
	Allorisma clavata or *maxvillensis*, Wh.	R. '007	G. Rom '179	Win	R. 118. 114, G. R. S. G. R. R. 12. M.
	Cf. *A. sinuata*	St. I., '213 N.I.	G. C. Win. '186	'247	G. R. Win.
	A. elongata n. s.	'007 '171	'189 '189	'247	G. R. S. M.
	A. quadrata n. s.	'008	'180		G. R. S.
	Cf. *Lithodomus jenkinsoni* (*A. sulcata.*)	'008		Win	G. R. Win.
	Nucula ?			Win ?	G. R. ?. Win. R. G. R. ? Win.
	Myalina lamellosa				G. R. S.
	M. Swallovi				
	Schizodus chesterensis Wh.	'218			M. G. R. R.
	Cypris or *Cythere*	R.			G. R. S.
	Aviculopecten ? Streptorhyncus ?	'218			Wh.
	Euomphalus ? similis	Lane ?			G. R. S.
	E. rugosus				G. R. Win.
	E. latus				Wh. B.
	E. planodorsatus				Bellevue. Win.
(8)	*Phillipsia* sp. *longispina*	N. I. '195 '214	G. Win. '177 '184 '185	'246	G. R. Win. R. G. R. S. Wl. G. R. Wh.
	[Phacops bufo ? Decamp]				G. R. Wh.
	Phillipsia ? cf. *brongiarti*	N. I.			
	Cladodus irregularis (Strong)	R. '196	R.		Win. G.R.S. R. R. 113.
	Psammodus				G. R. S.
	Ctenacanthus gracillimus ?		'196		G. R. S.
	Helodus crenulatus	R.	'196		G. R. S. Wh.
	Straparollus similis		'246		M.
	Naticopsis ziczac. Wh				M.
	Holopea newtonensis				M.
	Macrocheilus subcorpulentus				M.
	Polyphemopsis melanoides				M.
	Bellerophon sublævis or *B. magna*	'000 '210 '002			G. R. S. R. 113. Wh. M.
	" *ellipticus*				G. R. S.
	" *disciformis?*				G. R. S.
(9)	*Nautilus spectabilis*				M.
	kentensis				G. R. S.
	Nautilus pauper		'196 '252		M.
	ellipticus				G. R. S.
	Porcellia nodosus ?				G. R. S.
	Pleurotomaria (*chesterensis*) *subsinuata*				G. R. S.
	Goniatites discoides				M.

Table VII. Fossils of the (Maxville) Bayport limestone.

Notes on the table of fossils from the Bayport and kindred limestones.

(1.) The Lithostrotia are figured by Rominger, Vol. III, Pl. LV, also *Zaphrentis spinulosa*.

(2.) At least four species of bryozoa are well preserved in the Shebeon specimens.

(3.) The chert nodules, which occasionally contain fossils are often pear shaped, with a pit in one end, and apparently there are outlines of sponge spicules in the chert, but Girty found that sections show almost no organic remains.

(4.) The genus Productus is protean. It is impossible for me to eliminate the synonymy. Rominger referred the Producti almost uniformly to *flemmingii*, probably referring to Hall's variety.* Many of them are much like this. But on the other hand there are forms (Sp. 19176), which have marked concentric corrugations of the pattern of *Productus costatus*. Girty finds two species, one *P. punctatus*.

(5.) The Survey specimens, especially the numerous ones in Sp. 19246 are small, and seem nearer *A.*

trinucleus. There may be terebratuloids among the forms which we have referred to Athyris.

(6.) The specimens which we have collected from the same locality and can hardly be other than those which Winchell has referred to *Spirifer keokuk*, are distinctly punctate, with line of growth also running back on the ribs. The sinus and fold are variable, either smooth or with one or two ridges. There are about five ridges on either side. The strongly inrolled beak, shape of area, etc., are as Winchell described and like Whitfield's figure of *Sp. rockymontana*,† I cannot but refer it to *Spiriferina spinosa* which is a good deal like *Spiriferina kentuckyensis* and suspect that Winchell's, perhaps also Whitfield's specimens were imperfectly preserved.

*Geol. Iowa, 1858, Vol. 1. = *P. burlingtonensis*.

†Ohio reports, Vol. VII. Fig. 20, Pl. IX.

(7.) The Allorismas are another protean genus, occurring in great variety of size and form, but most frequently having the sinus from the beak to the ventral margin nearly or quite unobservable. The external ligament is shown by the very frequent occurrence of the shells in pairs, sometimes closed, often spread apart. In sandier layers the shells seem liable to reach a larger size. There are at last two varieties, a small type of which mawwllensis Whitfield and quadrata Strong seem to be names, and a larger type at times not essentially distinguishable from subcunectia,, to which the descriptions of *A. andrewsi* Whitfield and *A. elongata* Strong A. seem to be applicable.

Strong's descriptions of *A. elongata* and *A. quadrata* are as follows:

"No. 46. *Allorisma elongata*. (n. sp.) Like the above [*A. sinuata*]" except more elongated posteriorly, wholly without sinus upon the ventral margin or depression upon the valves, and beaks nearer the anterior end. An undistorted specimen of medium size gives the following measurements: Length, 64, height to hinge line, 23.5; height to summit of beaks, 25.4; greatest thickness, 20. Beaks one-ninth the length of the shell from the anterior end (varying in different specimens from one-seventh to one-tenth); twenty-eight concentric ridges —which in this case are pretty persistent—can be counted upon each valve. A specimen one and one-half inches long gave analogous results.

"No. 47. *Allorisma quadrata*. (n. sp.) Like the above, except smaller, relatively broader, with posterior end more quadrate. A specimen of full size, and *undistorted* gives the following measurements: Length, 31; thirty-nine concentric ridges in fasciculi of two, three, or four which often unite upon the posterior end.

"(The author has recently endeavored to refer to the above species described several years since, about seventy specimens, collected this season. He finds none of No. 45, fourteen of No. 46, forty-one of No. 47, and a remainder of heterogeneous material including a few individuals strongly resembling Owen's figure of *A. regularise* a few not unlike *A. clavata*, and almost every degree of variation between these forms and the three described above. Many resemble Fig. 2, Pl. 22, Vol. V., Pal. Ills. He had formerly believed, that Nos. 46 and 47 were distinct from No. 45, as he had never found them in the same horizon; but recently he has found the two former associated in strata 3 and 4, Taylor's quarry. It is questionable whether we have more than one species of this genus)."

It will be seen that he is inclined to consider them both varieties of *A. sinuata*. As varietal names I think they will stand.

(8.) Strong's description of *Phillipsia longispina* is as follows:

"No. 14. *Phillipsia longispina*. (n. sp.) Outline elongated elliptical sides nearly straight, ends evenly rounded; head, thorax and pygidium nearly equal in breadth.

"Glabella with posterior lobes small, anterior moderately large, evenly convex, without margin; facial suture nearly as in *P. Portlockii* neck segment about as wide as the thoracic, and continued backward in a narrow spine which extends beyond the thorax and is applied so closely to it as not to interfere with the elliptical outline; neck furrow shallow, curving backward strongly and terminating at the lateral furrows of the cheeks. Thorax and pygidium much as in *P. Portlocki* except that the border of the latter is very broad, equaling in breadth the lateral lobes. One specimen from Scribner's quarry yields the following measurements: Length, 44.4; of head 15.3; of thorax, 12.1; breadth of head, 21.2; of thorax, 21.9; of pygidium 20.4."

We may add as applicable to our specimens, eye facetted, kidney shaped, very prominent.

Axis of pygidium very high, continued nearly to the end, with 11 or more segments, margin smooth. The axis and the thoracic segments on each side are ornamented with a row of tubercles. All of our specimens show pygidium or glabella or eye, or cheek spine as separate fragments, but Strong had a nearly complete specimen, and I have seen one in the collection of Mrs. W. L. Webber of Saginaw. The species is a well marked one and wherein it differs from *P. portlocki*, approaches coal measure forms.

(9.) In the Bayport quarries I could see traces of large coiled shells, but was not able to extract them, and do not know whether they belong to Euomphalus or Nautilus, beside the Bellerophon form.

Girty collected some large coiled shells from the Bayport quarries which proved to be a robust species of Bellerophon—all internal casts and species not yet determined.

ERRATA.

[original document]

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