GEOLOGY OF WASHINGTON ISLAND AND ITS NEIGHBORS, DOOR COUNTY, WISCONSIN

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GEOLOGICAL SETTINGS OF THE ISLANDS

Location.—Door Peninsula, the long finger-like extension of northeastern Wisconsin that separates Green Bay from Lake Michigan, is carried northward across the entrance to the bay by a string of islands that ends at the Michigan mainland. The boundary between Wisconsin and Michigan passes eastward between Rock Island on the south and St. Martin on the north. This report will deal exclusively with the islands lying south of the boundary in Door County, Wisconsin.

Geographic relations.—The islands from north to south are Rock, Washington (with little Hog Island [Fig. 1] about one-half mile off the eastern shore and several small sand bars and islets in Detroit Harbor), Detroit, Plum, and Pilot (Plate 1). In area they rank as follows: Washington, about 23 square miles; Rock, about 1½ square miles; Detroit, about 1¼ square miles; Plum, about ¾ of a square mile; and Pilot, only a few acres.

A "submarine" cable connects Rock to St. Martin on the north and to Washington on the south, Washington and Pilot to Plum, where the Coast Guard Station for the area is situated, and Plum to the mainland of Door Peninsula. Mail comes to Gills Rock at the tip of the peninsula, via Ellison Bay, and is delivered by boat to the several islands.

An automobile and passenger ferry makes several trips daily between Gills Rock and Detroit Harbor on Washington Island, depending on the weather and season of the year. Local motor boats must be hired if one wishes to visit Detroit, Plum, Pilot, or Rock islands. In cold winters, the water about and between the

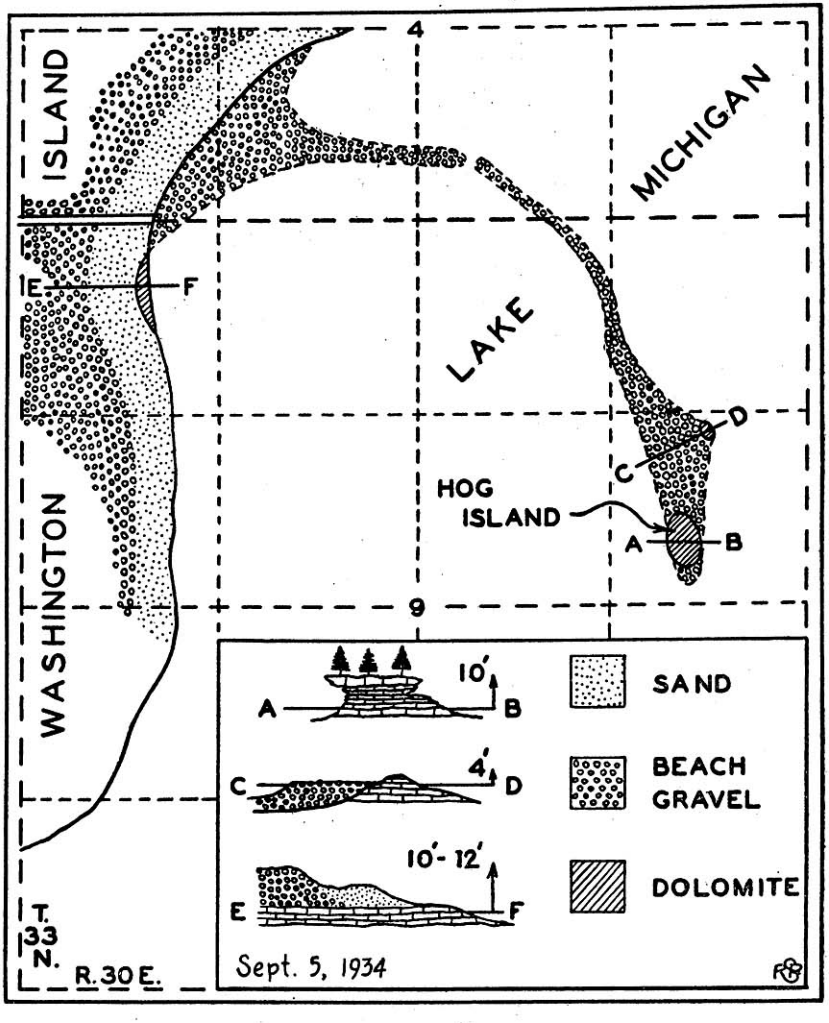


FIG. 1. Sketch map of Hog Island and a portion of Washington Island adjoining.

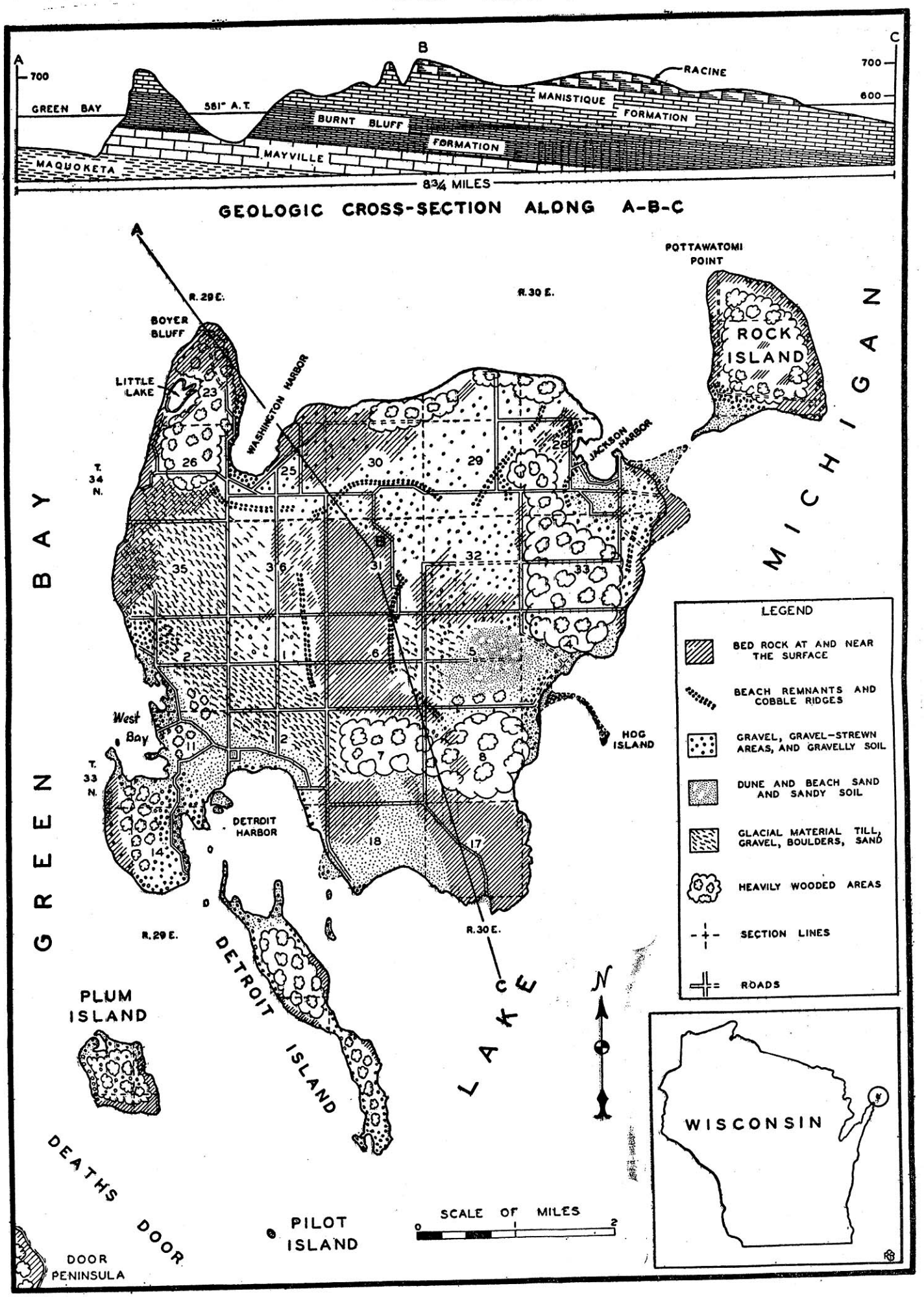


PLATE 1. Geologic map of Washington Island and environs with a geologic cross-section.

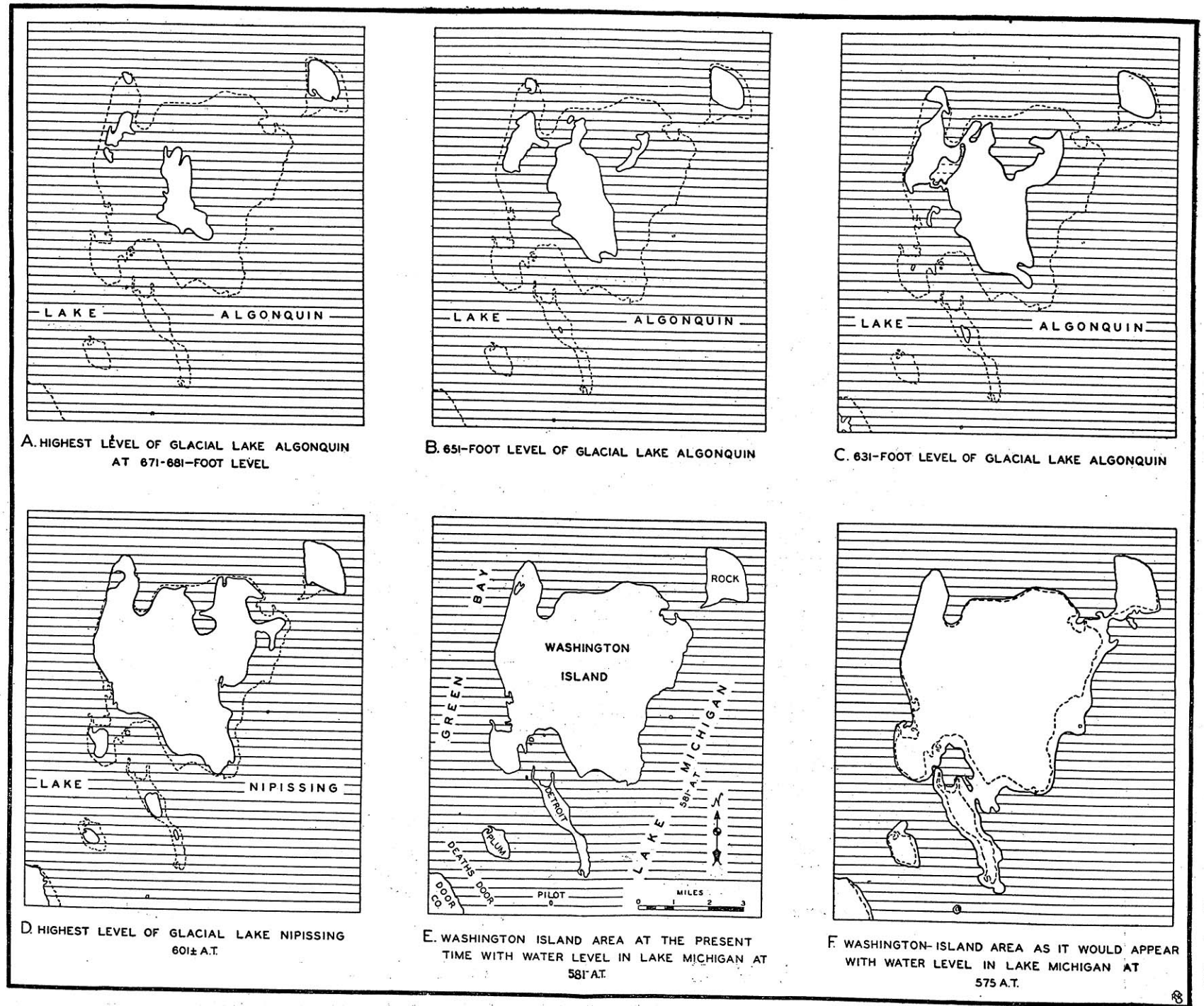


PLATE 2. Chart showing the glacial lake history of the Washington Island region.

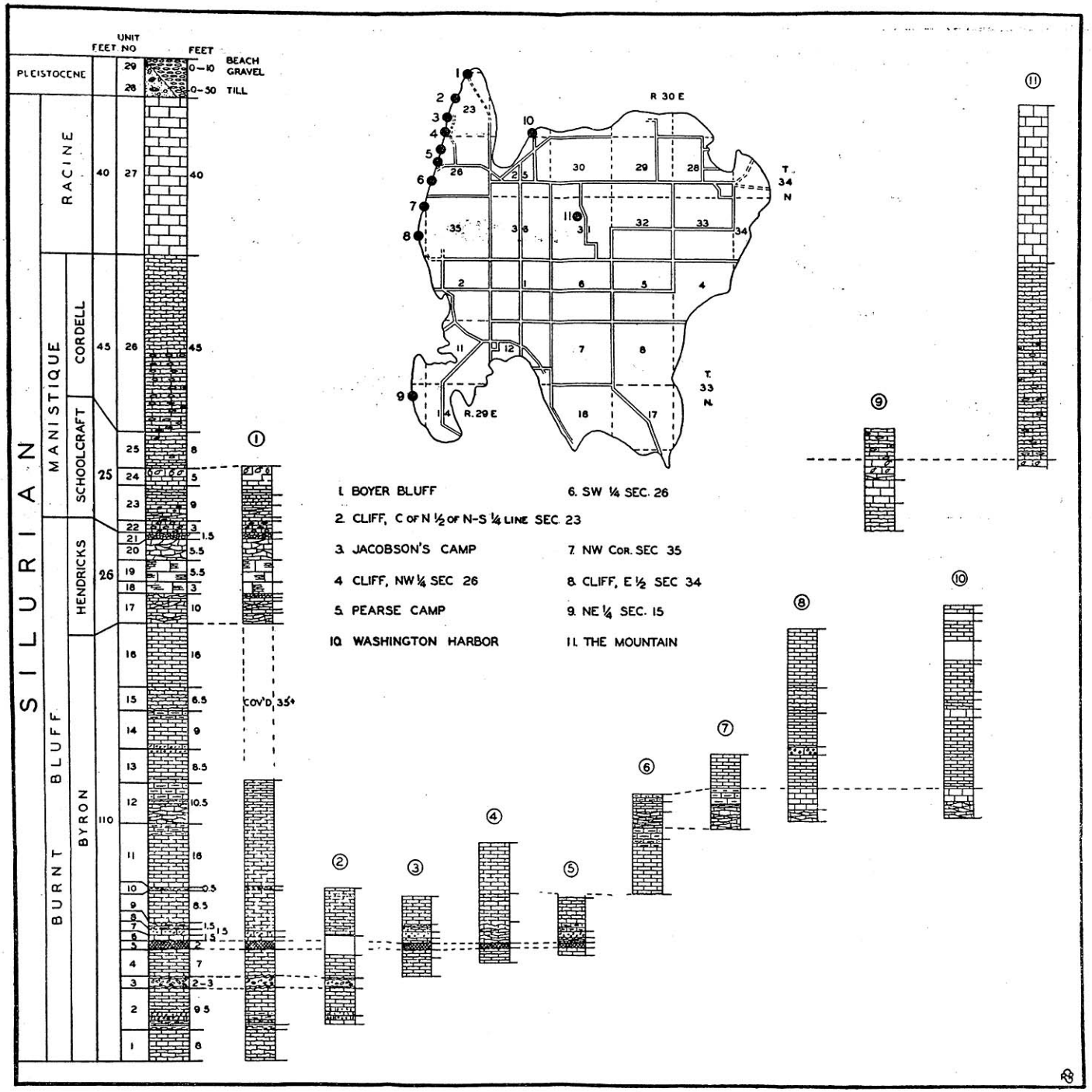
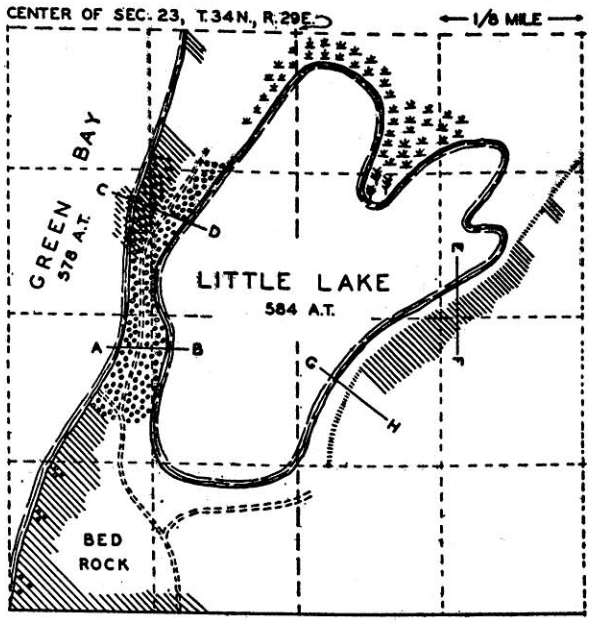
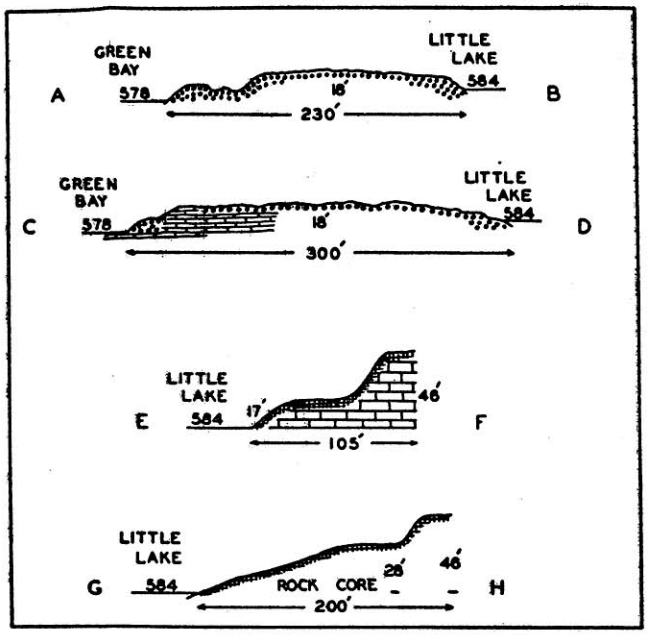


PLATE 3. Generalized geological column, and stratigraphical sections, of Washington Island. Correlations with Michigan formations are shown at the left of the chart.



D. LITTLE LAKE AND ENVIRONS, SEPTEMBER 3, 1934



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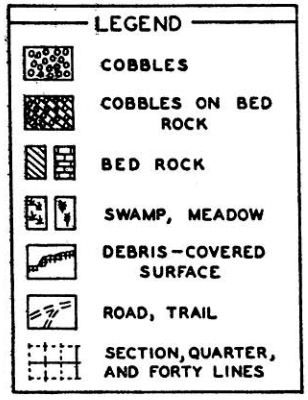
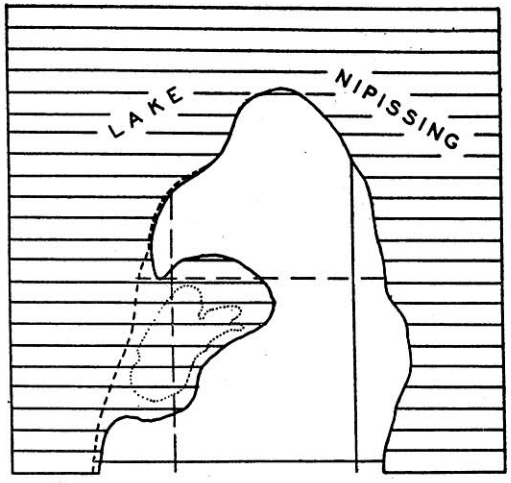
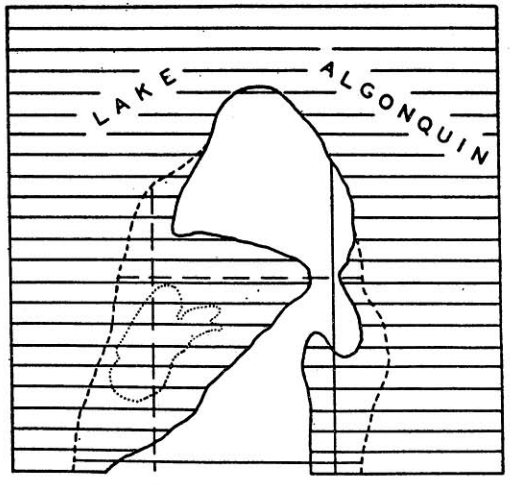




C. LATE ALGONQUIN — EARLY NIPISSING
601' LEVEL



B. LATE MIDDLE ALGONQUIN
631' LEVEL

A. EARLY MIDDLE ALGONQUIN
651' LEVEL

PLATE 4. Diagrammatic sketch maps showing the geological history of Little Lake.

islands freezes to sufficient thickness that automobiles can be driven from the mainland to the islands. This is not always a safe practice, however, for thin ice and open water have taken their toll, along with wind and storm, in Deaths Door.

Niagara Escarpment.—One of the most spectacular surface features in eastern Wisconsin is the Niagara Escarpment or "The Ledge" as it is called locally. It is a steep, westward-facing cliff that rises out of the glacial drift a few miles south of Waukesha and increases in height northward until it stands over 100 feet above the northern end of Lake Winnebago at High Cliff. It then dies out for a short distance, but soon appears as a low bluff east of Green Bay, and clinging to the eastern shore of the bay it increases steadily in height until it culminates in the bold, precipitous cliffs at Eagle Point Park near Ephraim and at Ellison Bay near the northern end of the peninsula. The cliffs at their greatest height rise over 150 feet above the waters of Green Bay.

Northward from the tip of Door Peninsula, the escarpment base becomes submerged beneath at least 140 feet of water; yet because of increased height it still rises well over 140 feet above water in Boyer Bluff, at the northwestern tip of Washington Island, and in the precipitous, triple-notched cliff at Pottawatomi Point, Rock Island (Plates 1 and 6).

The Niagara escarpment may be traced quite easily on the U. S. War Dept. Chart No. 715 (*Entrance to Green Bay, Lake Michigan*) by following the soundings. It is interrupted at Deaths Door Passage (Porte des Morts Passage) by the deep water in a transverse subaqueous valley, but it continues along the western side of Plum Island, thence due north along the western shore of Washington Island to Boyer Bluff, where it turns abruptly eastward to follow the northern shore almost to Rock Island. Then it makes a second right angle turn, this time to the northward, and maintains that direction along the western shore of Rock Island to Pottawatomi Point. Here it is again interrupted by a deep, transverse valley, which is now occupied by the Rock Island Passage, and it does not appear again until St. Martin Island in Michigan is reached.

If the waters of Green Bay and Lake Michigan were lowered 200 feet, the archipelago across the entrance to the bay would then appear as a rather narrow, serrated ridge with a pre-

cipitous cliff—the Niagara Escarpment—along the west side, and a rather steep, eastward slope along the opposite side. Before the glaciers overrode this part of Wisconsin and Michigan, therefore, there seem to have been two major valleys with numerous tributaries bounding the ridge just mentioned. The deep channels now occupied by Deaths Door and Rock Island passages were apparently sites where the tributaries of the two major valleys had been approaching each other by headward erosion and had already lowered the ridge considerably below its summit.

Glacial history—The glaciers, coming from the north and northeast and feeling their way southward, first sent great lobes along the two valleys and then finally rode bodily over the intervening ridge, grinding down, smoothing off, and grooving large areas of solid rock and leaving large boulders of igneous rocks not native to this part of Wisconsin on the highest parts of Washington and Rock islands. The lobes must have deepened the valleys many tens of feet, perhaps in the case of the Lake Michigan valley hundreds of feet, and the last to advance along them left a series of crescentic ridges of morainal material at the south ends of the depressions now occupied by the bay and the lake. The main lobe, which followed the eastern valley, deepened it far below what the pre-glacial stream could have done, and as a result the present bottom of Lake Michigan is in some places as deep as 289 feet below sea level. In contrast, the deepest point in Green Bay is 437 feet *above* sea level.*

The last sheet of ice to advance upon Washington Island left a thick morainic blanket of bouldery till over the northwestern quarter of the island. As it melted back, the escaping waters collected in the deepened basins occupying the former river valleys and the Great Lakes came into existence. At an early stage the ancestor of present Green Bay and Lake Michigan, called glacial Lake Algonquin, was considerably larger than those two bodies of water are today and also 90-100 feet deeper. At this time the island group under discussion was reduced to a few small islets (Plate 2). This old level is indicated at several places on Washington and Rock islands by caves and benches cut by the waves, and possibly by some of the higher beach remnants (Compare Plates 1 and 5).

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* "College Physiography", R. S. Tarr and L. Martin, The Macmillan Co., 1921, p. 326.

After a period of unknown length, the water level fell some 30 feet to approximately 650′ A. T., and remained at that general elevation long enough for benches and caves to be cut and for cobble ridges to be formed. Again the water level fell, this time about 20 feet to approximately 630′ A. T., and the same features came into existence as before, except at a lower elevation and around the increasingly larger island. Finally, water level dropped about 30 feet, to an approximate elevation of 600′ A. T., and glacial Lake Algonquin came to an end.

The 600-foot stage appears to have persisted for a considerable length of time, judging from the extensive rock benches and caves that were eroded into the resistant dolomites, and the widespread, dolomite cobble deposits that were made and deposited on the benches and in the caves. These shore features are well developed at many points on Washington Island, as well as on Rock Island, and some of them are indicated on Plates 1 and 5. This old level, which marks the closing stage of Lake Algonquin, also marks the highest level of the next lake, which has been named glacial Lake Nipissing. Hereafter, therefore, the 600-foot stages will be referred to as the Nipissing stage; the others at higher elevations as Algonquin stages. (Plate II).

From the 600-foot stage the water apparently fell about to its present level of 580′ ± A. T., or approximately 100 feet lower than at the beginning of Lake Algonquin.

Plate 2 has been constructed to show the shore lines at the various stages of lakes Algonquin and Nipissing, the present approximate shore line (at elevation 578.50′ A. T.), and the shore line as it would appear if water level were to fall another 3½ feet to elevation 575′ A. T. It is interesting to note that in the last condition Rock and Detroit islands would be joined to Washington, but deep water would still separate this superisland from Plum and Pilot islands, and the latter would also remain separated from Door Peninsula.

During the long period of time that has elapsed since the glacial ice melted off the continent and the enlarged Great Lakes gradually shrank to their present outlines, the earth's crust has been slowly readjusting itself to the unloading that took place with the removal of the ice. One way in which this readjustment has become obvious is in the gentle tilting of the beaches of the older stages; hence, the present elevations of the Algonquin

stages as marked on Rock Island are somewhat higher than the same appear on Washington Island and farther south along the Green Bay and Lake Michigan shores. The Nipissing level, on the other hand, appears essentially horizontal. For a full discussion of this very interesting aspect of the early history of Green Bay and Lake Michigan, the reader is referred to the Wisconsin Geological Survey reports by Goldthwait and Martin.

General geological sequence.—All of the stratified rocks exposed in the Washington Island region are dolomites belonging to the Niagaran division of the Silurian period. They make a great tablet which is inclined to the eastward with an average slope of about 30-40 feet to the mile, hence the eroded western edge of the tablet is very steep (Niagara Escarpment), whereas the eastern backslope is rather gentle. The strata are subdivided into a number of formations and these in turn, into members.

Fossils are not common in most of the rocks, and the uninitiated would soon conclude that they were absent, but many beds do contain a few and certain layers are quite full of them. In fact, some of the beds are so fossiliferous that they have been designated the "coral beds". A few of the common fossils are illustrated in Fig. 12.

The youngest geological deposits belong to the Pleistocene glacial period and consist of glacial drift and boulders, beach gravels, and beach and dune sand. They are scattered irregularly over the islands and vary considerably in thickness (Plate 1).

Washington Island

General surface features.—Washington Island is roughly rectangular in shape, with a maximum length of 6¼ miles, and average width of about 5 miles, and an area of approximately 23 square miles. Except for the cliffed western edge and the high backbone of the island, the general surface is gently rolling. There are few streams and these are short, because the natural lakeward slope of most of the island allows easy drainage without much concentration along stream channels.

Washington Island is essentially a large, differentially sculptured block of dolomite tipped gently to the southeast so that the individual beds or layers in the block, when followed for a

few hundred feet, are seen to descend in a general southeasterly direction at the rate of about 30-40 feet per mile. When these beds are examined extensively and in detail, however, they often show local irregularities which sometimes reverse the regional dip for short distances. A few exposures showing the dip of the beds may be cited in support of the general statement just made.

In the low cliff along the western shore northwest of the ferry landing the coralline strata dip gently to the southeast. Beds which outcrop at lake level in the N.E. ¼ of Sec. 34, T. 34 N., R. 29 E., also outcrop at the same level at Washington Harbor settlement, in the S.E. Cor. of Sec. 24, T. 34 N., R. 29 E., and a line drawn through these two points would trend in a northeasterly direction, at right angles to the regional dip, and would indicate the strike of the beds. Essentially the same direction of strike may be obtained by comparing sections 9 and 11 on Plate 3. Because of the southeasterly dip, successively older or lower strata are found at water level as one traverses northward along the western shore of the island, until at the tip of Boyer Bluff, the oldest rocks visible on Washington Island lie at water level.

Along the western shore at Pearse Camp (Plate 3) there is some local irregularity of structure, with dips varying from 18 to 53 feet per mile to the south and southeast within short distances. There is a low dome with maximum relief of perhaps 4 feet just south of the camp.

Local irregularities are again apparent in the vicinity of the rocky platform at the northeastern corner of the island, where for short distances the dip is northeasterly instead of southeasterly, as at Arnold Wickman's cottage in the S.W. Cor. of Sec. 34, T. 34 N., R. 30 E.

The most conspicuous topographic feature of Washington Island is the high cliff along the western shore which rises preciptously out of Green Bay. It begins at the southwestern corner of the island as a low, cobble-covered bluff about 15-20 feet high, and northward becomes increasingly higher until it culminates in the bold face of Boyer Bluff at the northwestern extremity of the island, where the highest point is over 140 feet above the bay (Figs 4, 11). A second prominent topographic feature on Washington Island is a high, rounded, double ridge in the central part, which is locally referred to as "The Mountain".

This twin ridge, which really consists of three ridges if the lower and westernmost one is included, is roughly stream-lined in a general north-south direction, presenting two high, rounded cliffs to the north and a long and broad, gently descending, irregular backslope to the southeast (Plate 5). The cliffs rise about 100 feet above the flat lowland to the north and about 160 feet above the level of Green Bay.

The backslope of the cuesta is fairly broad and slopes gently to the southeastern tip of the island where it continues under the water of Lake Michigan. One could walk on the same kind of dolomite, with occasional interruptions because of soil, gravel or vegetation, from the peak of "The Mountain" to the southeastern tip (See geologic cross-section on Plate 1), and if he could follow the same bedding surface all the way, he would descend about 160 feet in 8 miles, or at the rate of about 20 feet per mile. On the backslope of the eastern ridge are very prominent outcrops of the marble-like Racine dolomite which caps the hill, and the surface is in some places deeply corroded along prominent, enlarged joints, so that it resembles a giant pavement laid with huge rhombic blocks. (Fig. 10).

The glaciers which came from the north must have ripped away many tons of rock from the steep, northern faces of "The Mountain", and a lobe gouged out a typical U-shaped glacial valley between the two ridges. Down the backslope at several places the dolomite is smoothed and striated, and numerous grooves show that the general direction of ice movement was southerly. At the crossroads, where Secs. 5, 6, 7, and 8 corner (Plate 1), well preserved grooves show bearings that vary from N-S to N 15° W., and at the S. W. Cor. Sec. 31, T. 34 N., R. 30 E., similar markings vary from N-S to N 15° E.

STRATIGRAPHICAL SEQUENCE

The strata exposed on Washington Island total about 300 feet in thickness and belong entirely to the Silurian system except for the surficial gravels, sands, and silts that are of glacial or Pleistocene age. A generalized stratigraphical column is shown on Plate 3 and will be described in detail on the following pages. This generalized column is a composite sequence based on a number of scattered exposures as indicated on the index map of Plate 3. It has been subdivided into numbered units so that

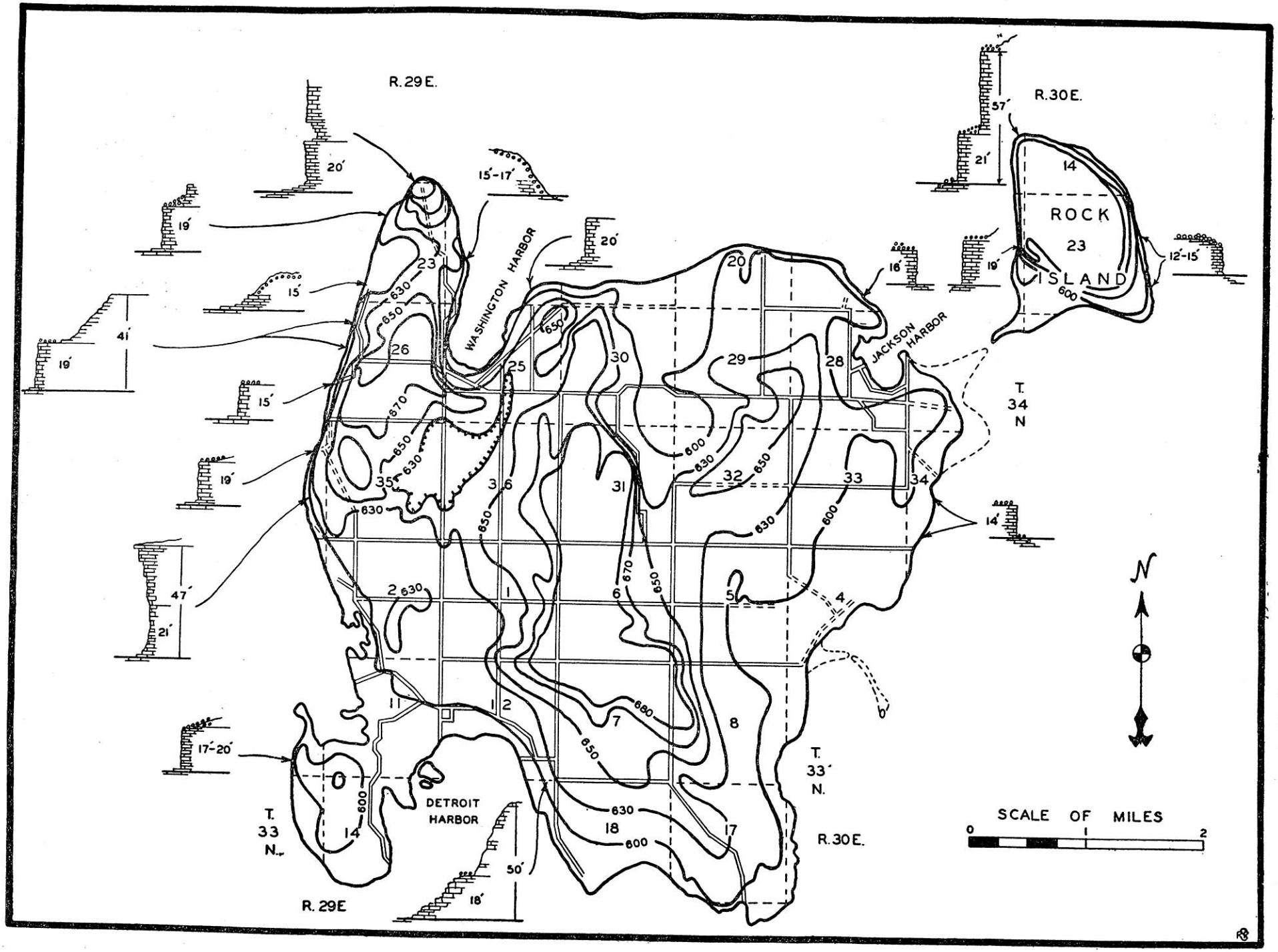

PLATE 5. Rock benches and ancient shore lines on Washington and Rock Islands, showing approximate shore lines of glacial lakes Nipissing (600′ A.T.) and Algonquin (630′‡, 650′‡ and 670-680′‡).

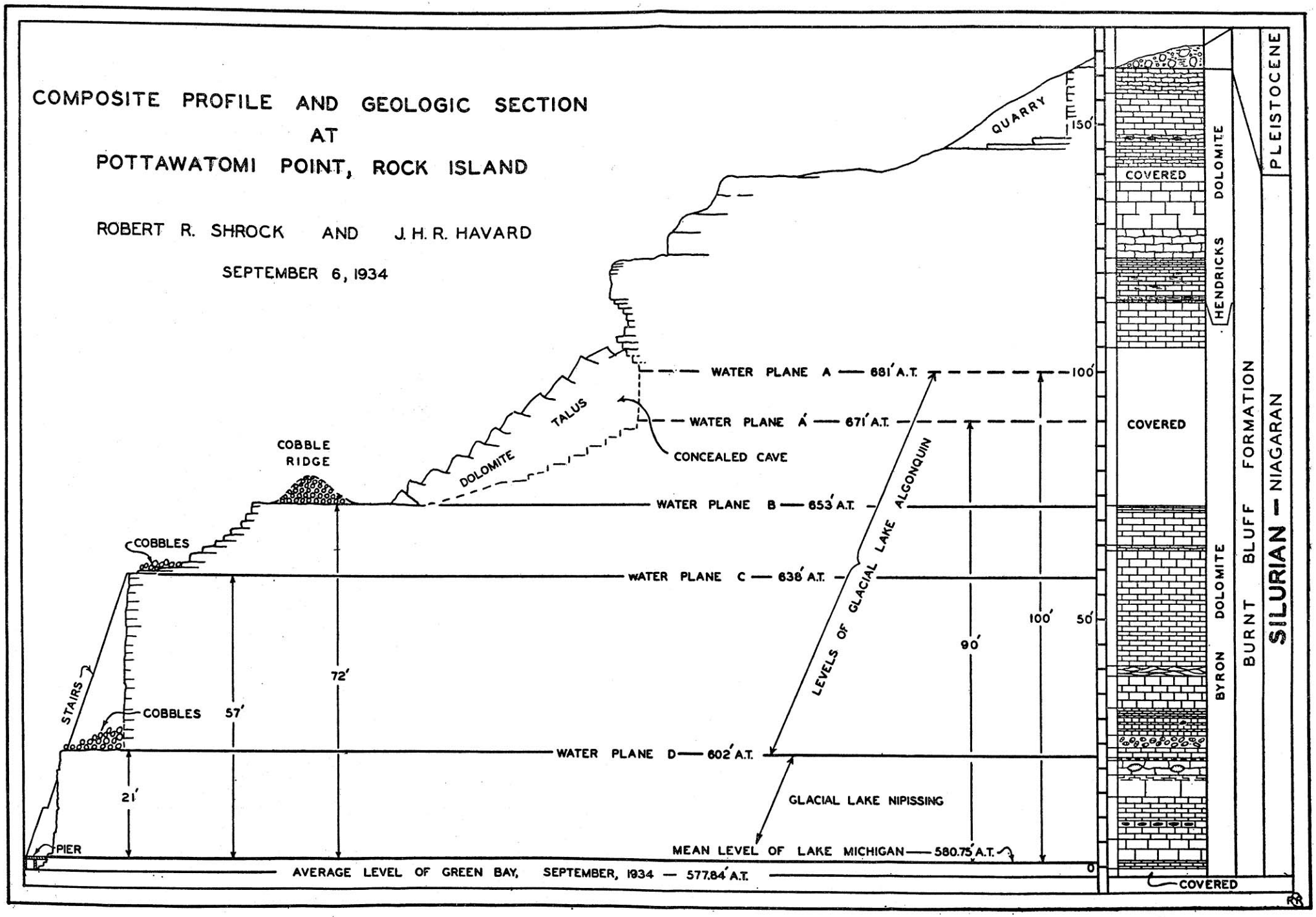

PLATE 6. Geological cross-section of Pottawatomi Point, Rock Island, showing stratigraphical column and evidences of ancient lake levels.

specific beds may be referred to easily. The names of the larger subdivisions (Racine; Manistique, consisting of the Cordell and Schoolcraft dolomites; and Burnt Bluff, consisting of the Hendricks and Byron dolomites) are those now in general use among geologists, but they are not in all instances the designations used by the earlier Wisconsin geologists. For this reason, the newer and older names are correlated in the chart below so that their equivalents may be determined at a glance. Racine and Byron are old Wisconsin names; Burnt Bluff, Manistique, Hendricks, and Schoolcraft are names that have been proposed for Michigan formations, that are well exposed in the Green Bay region.

TABLE 1. *Chart showing new and old names for beds exposed in the Washington Island area*

		New Classification (Shrock, 1934)	Old Classification (Chamberlain, 1873-1879)
SILURIAN-NIAGARAN	Racine Formation	Racine dolomite	Racine dolomite
	Manistique Formation	Cordell dolomite	Upper Coral beds
		Schoolcraft dolomite	Lower Coral beds
	Burnt Bluff Formation	Hendricks dolomite	Transition beds
		Byron dolomite	Byron dolomite

In the following detailed description of the numerous units of the generalized column, the unit will be referred to by the number which appears on Plate 3.

CENOZOIC—Quaternary—Pleistocene

29. Beach ridges and veneer of well rounded igneous, metamorphic, and dolomite cobbles and pebbles, sometimes containing fresh-water clam shells and marking the ancient shore lines of glacial lakes Algonquin and Nipissing. (0′-10′).
28. Glacial drift occurring at various places in hummocky moraines, irregular hillocks, and as a veneer of variable thickness. Numerous large igneous boulders are scattered over the island, even on the highest points. (0′-50′+).

PALEOZOIC—Silurian—Racine Formation

27. Gray, bluish-gray and greenish-gray, tough, dense, marble-like dolomite in thick beds with inclined joints. The rock breaks into large boulder-like masses. There are many peculiar, concentrically ribbed structures which may be cf organic origin, and a few corals and trilobites. Well exposed on "The Mountain", and also on Pilot Island. (40′+).

Manistique Formation—Cordell dolomite

26. Dark gray, thin- and uneven-bedded, somewhat saccharoidal dolomite full of corals and other fossils which are often silicified, and containing numerous chert nodules and lenses in the lower half.

Well exposed at the base of "The Mountain", along the eastern shore at several places, and on Rock and Plum islands. (45′+).

Manistique Formation—Schoolcraft dolomite

25. Buff-gray, uneven-bedded, somewhat saccharoidal dolomite with considerable chert and numerous silicified corals and brachiopods (*Pentamerus*). Exposed just north of "The Mountain", in Washington Harbor, and along the shore northwest of the ferry landing. (8′+).

24. Buff-gray, fairly thick- and uneven-bedded, saccharoidal dolomite full of well preserved specimens of *Pentamerus*, many of which are silicified. In places the rock is a veritable coquina. The lower 1½′ weathers into nodular layers that are less fossiliferous. Exposed on top of Boyer Bluff and on the flat north of "The Mountain". (5′+).

23. Sequence of variable lithology, exposed near the top of Boyer Bluff just below the light tower, in descending order:

1′.	Gray, dense, hard and tough dolomite containing some silicified corals.
1½′.	Gray, dense, crystalline dolomite containing corals and weathering to buff, porous, sugary rock.
2½′.	Massive, buff dolomite full of silicified corals and weathering with a rough and ragged surface.
3′.	Light buff, uneven-bedded, nodular and platy dolomite with a few chert nodules in the upper half.
1′.	Brown, hard and tough, blocky dolomite.
9′..	Total

22. Gray-buff, soft, uneven-textured, saccharoidal dolomite full of white and gray-brown chert nodules and containing some poorly preserved pentameroid brachiopods. The chert is in nodules and discontinuous layers 1″-2″ thick. The rock breaks with shattery fracture into angular fragments. This unit is believed to represent the lowest horizon of *Pentamerus*, except for occasional specimens, and is taken, therefore, as the base of the Schoolcraft dolomite. (3′).

Burnt Bluff Formation—Hendricks dolomite

21. Buff, saccharoidal dolomite with uneven texture, tending to break with shattery fracture into nodular and irregular fragments. (1¼′).

20. Similar to unit 21, but somewhat less shattered and with many minute tubes ramifying the basal layers. The bedding is somewhat lenticular and uneven. (5½′).

19. Buff, massive, finely saccharoidal dolomite in two thick beds which split into thin laminae ¼″-½″ thick on protracted weathering. The upper 3′ bed is dark-brown to gray, dense dolomite which weathers to a sugary condition. (5½′).

18. Buff, massive bed of uneven-textured, granular dolomite which weathers with rounded and smooth surfaces into loose, buff, dolomite sand. (3′).

17. Gray-buff, massive, uneven-bedded dolomite which shatters on weathering into interwedging, lenticular masses, platy chips, and flakes. Beds of this rock alternate with one-foot layers of dense, gray dolomite which does not split on weathering. Partly exposed in Boyer Bluff and at the top of the Washington Harbor section. This unit is believed to mark the base of the Hendricks dolomite because the underlying strata possess the typical, blocky, semi-lithographic, even-bedded character of the Byron dolomite. (10′).

Burnt Bluff Formation—Byron dolomite

16. Gray, fine-grained, even-bedded, blocky fracturing, hard and tough dolomite separating along smooth surfaces into beds from 6″ to 1′ thick. Exposed in the E ½ of Sec. 34, T. 34 N., R. 29 E., in the Washington Harbor section, and elsewhere on the island. (16′).
15. Buff, massive, uneven-bedded, fairly hard and tough dolomite which weathers readily to cream-colored, dolomitic sand. The rock breaks into small chunks of irregular shape because of poor and irregular jointing, and hence contrasts with the blocky beds above and below. It has a buff color which also contrasts with the gray-white of the contiguous strata. There is commonly a slight indentation in cliffs where the unit is exposed because of its ease of weathering. (6½′).
14. Gray, dense, blocky fracturing, uneven-bedded dolomite similar to unit 16. The joints are not at right angles, hence the blocks have wedge shapes. The upper 3′ are somewhat massive and tend to have lighter color. The basal one-foot bed is dark-gray, somewhat saccharoidal rock with many small, flattened cavities disposed horizontally, weathering easily with a horizontally grooved surface. (9′).
13. Light brown (white-weathering), hard, tough, semi-conchoidally fracturing dolomite separating into even beds from 6″ to 1′ thick along smooth bedding surfaces. The smooth joints are at nearly right angles, hence the beds break into cubical or prismatic blocks. (8½′).
12. Buff, fossiliferous dolomite of sugary texture with upper 3′ to 5′ even-bedded and lower part unevenly bedded. The rock weathers to a harsh, dolomite sand resembling ashes. Corals are abundant throughout the unit. The separation planes in much of the unit are very bumpy and the beds of unequal thickness. In some sections, cavities a few inches across are present, apparently the result of solution, and some of the corals are partly silicified. In addition to corals (*Favosites* chiefly), there are stromatoporoids, brachiopods, and gastropods. This important coral horizon is exposed at several places at or just above water level in Green Bay (Fig. 3). (10½′).
11. Gray to light brown (white-weathering), hard and tough, brittle, dense, conchoidally fracturing dolomite in even-bedded layers 3″-8″ thick. The rock first separates into cubical and prismatic blocks and then after considerable weathering these split into thin laminae (¼″-½″ thick). There are a few mud cracks and ripple marks on some of the separation surfaces. The base of this unit is strongly marked by a very bumpy surface along which it separates from the underlying strata, though this relation is sometimes interrupted by a thin unit of laminated, carbonaceous shaly dolomite. (16′).
10. This unit is of interest because it may be marked by a foot or less of dark colored, horizontally streaked, crinkly laminated, argillaceous and somewhat carbonaceous dolomite; or this thin shaly unit may disappear, in which case its place is represented by the very bumpy surface separating units 9 and 11. (0′-1′+).
9. Gray to white-weathering, blocky, semi-lithographic, conchoidally fracturing dolomite in even beds from 6″ to 2′ thick or wavy, uneven beds of variable thickness. The rock weathers with a horizontally grooved surface and often develops scattered holes which owe their origin to solution of crinoid fragments. Mud cracks and ripple marks are common throughout, and small tubes ramify some of the beds. (8½′).

8. Rock is similar to unit 9 except that it is somewhat shaly, banded and laminated, and the bedding is billowy. (1½′).
7. Gray, massive dolomite full of large holes and always conspicuous in a weathered cliff.

   This unit can be traced from Pearse Camp (Plate 3) to and beyond Jacobson's Camp, being from 4 to 6 feet above water level. The rock is brown, has finely crystalline texture and semi-conchoidal fracture. Stratification is lacking, though the bed does tend to become slightly banded at the top on weathering.

   Numerous cavities are present and the bed thickens and thins so that the upper and lower surfaces undulate gently. Overlying and underlying beds thicken and thin in conformity or bend up and down.

   The cavities are generally flattened, average 2″-6″ long and 3″ thick and are often mainly spongy masses of dolomite. Many are partly filled with a reticulose mass of finely crystalline dolomite. In some instances, spongy masses occur in the bulges of the bed, but more often they occur where the bed is somewhat constricted. The origin of the cavities is not apparent. Some may be algal; others seem almost certainly the result of solution. (1½′).
6. A massive layer of dolomite with a rippled upper surface, undulating in conformity with the variations in thickness of unit 7, and a very bumpy lower surface which fits over the uneven surface of unit 5. There are numerous current ripple marks which are about an inch apart and have a general northeasterly trend with the water moving from the southwest. (1½′).
5. White, gray or brown, dense, semi-lithographic dolomite in a single massive bed with a very uneven upper surface. The relief on this surface is as much as a foot locally and there is no definite pattern to the irregularities. The unit is always conspicuous and just south of Pearse Camp it dips southeasterly at about 53 feet per mile. (1′-2′).
4. Gray to light brown, fine-grained, blocky dolomite with same general characters as unit 9. (7′).
3. Conglomeratic dolomite. This unit has a 6″-8″ layer of gray, semi-lithographic dolomite at the top and base, and between is massive, very uneven-textured, cavernous dolomite in which a thin (6″+) conglomeratic layer is commonly present. The lower bounding bed contains a few chert nodules, and undulates considerably in adjusting itself to the very uneven surface of the underlying unit. (2′-3′).
2. Gray to white-weathering, even- and fairly thin-bedded (1′+ thick), blocky, semi-lithographic, conchoidally fracturing dolomite. Some coarsely textured parts weather out causing small holes to develop, and the entire unit weathers with horizontal grooving into iron-stained, dolomite sand. The lower 2′ of rock shows some black, shaly, crinkled laminae alternating with a few thin dolomite layers. (9½′).
1. Gray, dense, blocky dolomite separating, along slightly uneven surfaces, into fairly thin layers (2″-12″ thick). Shale films separate many of the layers. This unit is at least 8′ thick, and probably is somewhat thicker for in September, 1934, it could be seen under water for some distance out from shore. Normally probably not over half of the thickness can be seen above water. (8′+).

It should be noted that the Boyer Bluff section has a total thickness of approximately 150 feet and that the complete column for Washington Island totals slightly over 250 feet.

SHORE LINE

General features.—The rather smooth shore line of Washington Island is broken by four prominent indentations: Detroit Harbor on the south; West Bay on the west; and Washington and Jackson harbors on the north. A small village is present in each of the indentations. Detroit Harbor is the largest of the settlements and has a good-sized hotel, the post office for the island, schools, and numerous other buildings.

Along most of the south shore a narrow zone of beach gravel gives way inland to dune sand and this in turn merges into the wooded hinterland. Along the western shore a cobble beach reaches from the ferry landing to Boyer Bluff with few breaks. The cobbles are predominantly dolomitic and of local origin, though there are some igneous and metamorphic cobbles and boulders of glacial origin. Back from the shore the beach ends in sand, as around West Bay, or against a rocky cliff topped by a veneer of ancient beach cobbles. The lowest of these ancient beaches is at an approximate elevation of 600′ A. T., or about 15 to 20 feet above present water level in Green Bay, and is considered the Nipissing level. It is of interest to reflect that rocky platforms and cobble ridges, in all essential characters exactly like the ancient ones, may be seen in the process of formation at many points along the present western shore of Washington Island (Fig. 11).

The northern shore is margined with a cobble beach and is wooded along much of its extent. There is considerable sand opposite Rock Island and also along the eastern shore south of the cobble-veneered platform at the northeastern corner of the island.

The eastern shore varies from rocky cliffs to low terraces of gravel and sand (Plate 1). At several places the Nipissing level may be identified by rock benches and cobble ridges.

The materials along the present beach consist of the following:

1. Large blocks and slabs of dolomite recently fallen from a cliff or torn from the exposed rock along the shore by waves and winter ice. (Fig. 4).

2. Roundstones of dolomite ranging in size from that of an apple to that of a basketball or large pumpkin. These are the cobbles of future beach ridges.
3. Small rounded cobbles, and a few boulders and pebbles of granite, basalt and metamorphic rock.
4. Gravel consisting of angular and rounded pebbles of dolomite, often piled in windrows a foot or so above water level. Ridges of such material that are now from 5 to 8 feet above the water (elevation 585′+ A. T.) are thought to have been deposited during some past stage of unusually high water as in 1929, when the level reached 582.25′ A. T. during the summer.
5. Beach sand, almost certainly of glacial origin, occurs at a few places and usually forms a strip parallel to the shore, though it may also reach inland for some distance (Plate 1).

Along rocky shores there are overhanging cliffs, stair-stepped rocky platforms a few feet above or below water level, and colonaded cliffs, with square or prismatic columns marked off by prominent, smooth, vertical joints (Fig. 4). Caves have been quarried out of some of the cliffs by waves and winter ice, and these may be seen at several levels. (Fig. 11).

Little Lake.—Little Lake, one of the choicest beauty spots on Washington Island, lies in a shallow bowl of forest and meadowland and is separated from Green Bay by only a narrow strip of bed rock and cobbles (Plate 4). It lies in the extreme northwestern corner of the island on the peninsula which separates Washington Harbor from Green Bay, in Sec. 23, T. 34 N., R. 29 E. It is roughly r-shaped, with an area of about 130 acres, and its longitudinal center line bears generally northeasterly. By hand level the water surface was found to be six feet higher than Green Bay. Since the normal level of Green Bay is about 581 feet above sea level, the level of Little Lake would be about 587 feet. It should be pointed out, however, that the water level of the lake rises and falls in response to that in the bay, for in September, 1934, with the water at 578′ A.T. in the latter, the lake surface stood at 584′ A.T. This low water condition was made obvious by the piers which were much too high for water level and in the rowboat harbors where the former shallow bottoms were high and dry.

According to Mr. Jacobson, who has a camp at the south end of the lake, the maximum depth that has been found in the lake is about 15 feet. He also stated that the bottom is covered to a large extent with mud full of decaying organic matter, and this

condition is further suggested by the tangle of weeds and grasses which fringe the shore. There are scattered boulders on the dry bottoms of the small harbors, and along the shore in general, and such are also very likely buried in the bottom muds.

The region around Little Lake is heavily wooded with evergreens and deciduous trees, and there is considerable underbrush. At the north end the lake fades into a marsh, and this in turn gives way to a narrow band of meadowland that extends northward to the heavily wooded slope rising toward the summit of Boyer Bluff (Plate 1).

A low bluff of Byron dolomite extends along the shore of Green Bay north and south of the lake, but disappears where Little Lake most nearly approaches the bay. In this gap an 18-foot, flat-topped ridge of dolomite cobbles holds back the waters of the lake from flowing into the bay. The top of this low bluff averages 15 to 18 feet above the bay (elevation = 595′ ± A. T.) and is nearly always a flat bench veneered with beach cobbles of dolomite, representing the shore deposits of Lake Nipissing.

The east side of the lake basin is bordered by a low, double-stepped escarpment extending in a general northeasterly direction. The lower bench, which has an approximate elevation of 600′ + A.T., represents the Nipissing level and the higher, which varies somewhat in elevation (624′ — 630′ A.T.), is believed to represent the 630-foot Algonquin stage. There are a few small caves in the lower escarpment. (Plate 5).

These two benches are without cobbles, but they are veneered with talus and soil. Apparently disintegration and decomposition have provided enough debris to cover the old beach cobbles, if any ever were present. Several small caves, similar to those that may be seen along the nearby Green Bay shore line, are present in the lower cliff and were probably cut at a time when the storm waves and winter ice of Green Bay could make their effects felt along this old shore.

Present geographical and geological relations indicate that Little Lake is of fairly recent origin, probably dating from sometime during the Lake Nipissing stage. In the early middle Algonquin, when the water level stood at 650′ ± A.T., the Boyer Bluff Peninsula was transected by a wide channel as shown on Plates 2B, 4A, and 5. As the water level fell to a lower stage

of 630′ ± A.T. this channel was destroyed by the emergence of the land, but a deep embayment still persisted on the Green Bay side. Finally, when the waters fell still further to 600′ ±, marking the close of the Algonquin and the beginning of the Nipissing stage, this embayment shrank considerably in size but still remained as a prominent indentation, open to the storm waves and probably the winter ice of the bay to the west. It was at this time, apparently, that the caves and rock bench were cut along the eastern side of the lake basin.

Shortly after the beginning of the Nipissing stage, however, it is believed that the storm waves, which must have thundered on the beaches even as they do today, and the powerful winter ice, that shoved with great force against the shore, gradually built a ridge of beach cobbles and talus across the mouth of the small bay and, thus blocked, the bay became the basin of Little Lake. The cobble ridge which acts as a dam averages about 250 feet in width and stands at an average elevation of about 596′ A.T., or about 15 feet above the average level of Green Bay. It would appear, therefore, that the lake came into existence not long after the beginning of Nipissing time.

Once cut off from the bay, the lake basin began to receive clay, silt, and organic materials from the surrounding slopes, and it is believed that these fine deposits gradually filled the voids between the coarser particles of the cobble ridge, ultimately sealing off the waters of the lake and thereby making it possible for the latter to maintain a level 6 feet higher than that of the bay. At the present time Little Lake appears to be fed by springs and the runoff from the surrounding slopes, hence in years of heavy rainfall the level will rise, as will that of Green Bay, whereas in years of drought it will fall.

Little Lake, then, appears to have been formed by the blocking of a preexisting bay of somewhat larger size, and this is further borne out by the presence of the old beach lines and wave-cut caves along the east side of the present lake basin.

Rock Island

GENERAL STATEMENT

Rock Island is the last and northernmost of the Wisconsin islands stringing across the entrance to Green Bay (Plate 1).

It has an area of slightly over 1¼ square miles and is roughly rectangular in outline with a low, narrow southwestern point reaching toward Washington Island. The western side of the island rises precipitously out of Green Bay to a maximum height of over 170 feet, the interior is quite rough with parts standing from 100 to 200 feet above water, and the northern, eastern, and southern shores show only low cliffs of dolomite bordered by cobbles and beach gravel, or by sand. Nearly all of the island is wooded, hence the best exposures are along the shore line where the waves and winter ice are always actively quarrying away the thin-bedded and well jointed rock.

There are said to be many deer on the island but we failed to see any, probably because of the noise we made while traversing the woods. Along the western or Green Bay shore, however, we counted six deer skeletons, apparently representing animals that had plunged over the precipice south of Pottawatomi Point during the previous winter. We were told that many animals meet death every winter in this manner when fleeing from dogs. The deer are known to cross back and forth from Rock to Washington island on the winter ice.

There is a lighthouse at the northwestern corner of the island, on top of Pottawatomi Point, and a family lives here throughout the year. The government owns a small area in the immediate vicinity of the light, but the remainder of the island belongs to C. H. Thordarson, a Chicago manufacturer.

THORDARSON CAMP

Mr. C. H. Thordarson has built a very beautiful group of buildings on the southwestern point of Rock Island, taking advantage of the local materials for building purposes and of the natural configuration of the surface in landscaping his camp. Most of the buildings, which include a large boathouse, a greenhouse, and numerous cottages, are constructed of rounded dolomite pebbles and cobbles laid in successive courses. The masonry is of the highest order and the architecture blends harmoniously with the landscaped surroundings. (Fig. 6).

The ancient beach ridges of dolomite cobbles have been preserved and utilized in the landscaping of the grounds; sand from nearby dunes has been utilized to some extent; cobble stones and glacial boulders have gone into the walls of the buildings and

into the fences; and the bedrock of the island has been used for foundations and in other ways. The Thordarson Camp is an excellent example of how effectively local materials and surface features may serve the builder and designer.

TRAVERSE OF THE SHORE LINE

West shore.—A traverse of the west shore shows a low bluff 12 to 15 feet high just north of the Thordarson Camp increasing in height northward to its culmniation in Pottawatomi Point, where there is a sheer precipice over 60 feet high, broken only by a narrow, wave-cut bench at about 24 feet above water level (602′ A. T.). The beds undulate considerably along the shore for some distance north of the camp, but by the time Pottawatomi Point is reached the dip has flattened out and changed to a slight easterly inclination of about 20 feet per mile. This gentle easterly dip may be traced along the northern shore of the island, and distinctive beds which appear 35 to 40 feet above water in the cliff below the lighthouse descend to water level along the eastern shore in a distance of about 1½ miles.

Pottawatomi Point.—Pottawatomi Point is a bold, precipitous cliff at the northwest corner of Rock Island. It is surmounted by a lighthouse which stands on a prominent rock bench about 140 feet above Green Bay. The light is cared for by a family which lives in the lighthouse during the entire year, and is in telephonic connection with the Wisconsin mainland.

The profile of the point is shown on Plate 6 and is very interesting because of the excellent preservation of the rock benches and cobble ridges marking the several levels of Lake Algonquin and the highest stage of Lake Nipissing. Apparently the waves cut a very prominent cave when the water stood at the highest Algonquin level (671′-681′ A.T.), but this feature is now almost completely concealed by talus. It is of further interest to note that the several benches are somewhat higher than contemporaneous ones along the Washington Island shore. This is due to the fact that the land surface was tilted slightly to the southward after the Algonquin benches were cut.

A careful section was measured at Pottawatomi Point and is described in detail below. It starts along the steep shore below the lighthouse and continues upward along the wooden

steps leading to the higher benches, thence up another stairway to the flat on which the lighthouse stands, and finally up the slope behind and south of the house, by way of the old quarry, to the highest point along the western shore. (Plate 6).

Geological Section of Pottawatomi Point, Rock Island, September 6, 1934.*

CENOZOIC—Quaternary—Pleistocene

27. Glacial drift containing large boulders of igneous rock and found on the high point a short distance south of the lighthouse. Thickness not over a few feet, though possibly greater in other parts of the island.

PALEOZOIC—Silurian (Niagaran)—Manistique (Schoolcraft) and Burnt Bluff (Hendricks) formations [contact not clear].

26. Buff, uneven-bedded, nodular, sugary dolomite once burned for lime and exposed in the upper part of the old quarry face. (5′).
25. Buff, soft and granular, somewhat laminated dolomite exposed in the quarry, in the cellar of a small building just east of the lighthouse, and in the top of the bluff on which the lighthouse stands (Plate 6). The basal 1½ feet are uneven-bedded and cherty. (10′).
24. Gray, even-bedded, blocky dolomite exposed in the cellar wall. (3¼′).
23. Buff, gray, nodular dolomite. (2′).
22. Covered. (3′).
21. White-weathering, massive, fine-grained dolomite fracturing conchoidally into smooth slabs and exposed in the cliff below the lighthouse. (4′).
20. Buff or gray, massive, granular dolomite in layers 6″-18″ thick and weathering to a dolomite sand. (5½′).
19. Brown, massive, sugary dolomite containing corals and breaking into irregular layers. This unit forms a prominent bulge in the bluff. (6′).
18. Light brown, lithographic dolomite in 3″ layers, fracturing conchoidally and containing many silicified corals (*Favosites*). (3′).
17. Gray to buff, even- and fairly thin-bedded, finely crystalline dolomite fracturing irregularly throughout, and splitting into platy chips in the basal part. (6′).

Burnt Bluff Formation—Byron dolomite

16. Gray, even-bedded, dense, blocky dolomite exposed in prominent caves below the lighthouse, and extending down to the 651-foot bench presumably, though the basal part of this unit and the underlying covered interval are now concealed by talus. (9′).
15. Covered by talus and cobbles of dolomite. Ancient beach gravel. (32′). (See Plate 6).
14. Light gray, lithographic, blocky dolomite that is thin-laminated in the upper few feet at the top of the bench but otherwise in beds averaging 6″-12″ thick. Exposed at top of wooden ladder. (8′).

* The section as shown on Plate 6 has been subdivided into numerous units which are not numbered because of the lack of space. The same units are numbered in this descriptive section.

13. Black, carbonaceous, crinkly laminated dolomite (1′).
12. Gray, even- and fairly thin-bedded (6″-12″), semi-lithographic, blocky dolomite with some lamination and horizontal streaking. The laminae are crinkly and in some layers resemble crude cross-lamination. The beds show mud cracks and ripple marks and the impressions of curved crinoid stems. A few fossils are present (*Conularia*, *Halysites* and *Phragmoceras*). (23′).
11. Gray, semi-lithographic, irregularly fracturing, uneven-bedded dolomite shattering into interfingering wedges on weathering. This unit is always prominent in a weathered cliff because of the irregular bedding. (2′).
10. Light gray, even-bedded, blocky dolomite breaking conchoidally into platy slabs and weathering to a mottled, bluish-yellow pattern. (6½′).
9. Dark gray, thin-laminated dolomite becoming streaked and rotten on weathering (5½′).
8. Gray, massive, dolomite conglomerate which on weathered surfaces shows flat, laminated dolomite pebbles in a gray, crystalline matrix of dolomite. (2′+).
7. Gray, semi-lithographic, even-bedded, blocky dolomite. (2′).
6. Dark gray, laminated, shaly dolomite splitting into paper-thin sheets. (½′).
5. Gray to blue, marble-like, cavernous dolomite full of holes a foot or more across, which are lined with radially directed calcite crystals. The lower 14″ is brown streaked. (3′).
4. One massive bed of gray, semi-lithographic dolomite breaking into conchoidally fractured blocks. The upper foot tends to become laminated on weathering. (4½′).
3. Gray, even-bedded, blocky, semi-lithographic dolomite with a band of brown-gray, chert nodules about a foot thick, 5 feet above the base. The upper foot is massive, angular fracturing dolomite more like the overlying rock. The unit as a whole becomes horizontally grooved on weathered surfaces. (8½′).
2. Gray, thin-bedded (2″-6″), argillaceous, lithographic dolomite which shatters into rounded fragments with marked conchoidal fracture. Extensive weathering reduces the rock to small chips. (6′).
1. Covered by talus from the cliff, but probably same as unit 2. The base of this unit is at water level in Green Bay on September 6, 1934. (1½′).

The contact between the Hendricks member of the Burnt Bluff formation and the Schoolcraft member of the Manistique formation could not be determined because the pentameroid bed marking the base of the latter could not be found. It may be assumed, however, that the Hendricks has about the same thickness here as in Boyer Bluff on Washington Island, hence the base of the Schoolcraft dolomite (as well as the base of the Manistique formation) should be at an approximate elevation of 727′ ± A. T., or somewhere in the wall of the old quarry (Plate 6).

East shore.—There is a low cliff of Byron dolomite along the east shore of Rock Island and at places it is veneered with beach cobbles representing the Nipissing level (Plate 5). This cliff, varying from 12 to 20 feet high, swings westward near the southeastern corner of the island and continues nearly to the Thordarson Camp near which it is lost beneath the well developed cobble terrace.

The following section was measured near the southeastern corner of Rock Island where a low, 18-foot, cobble-strewn, rock bench rises above a narrow rocky platform reaching out to the water line (Fig. 5). The strata dip gently to the northeast.

Section in southeastern corner of Rock Island,
in the S.E. Cor. of Sec. 23

CENOZOIC—Quaternary—Pleistocene

4. At the top of the rock bench there is a veneer of dolomite beach cobbles which are believed to mark the shore line of glacial Lake Nipissing. The lowest of these cobbles are 13′ 9″ above lake level (1934), and the highest slightly over 17½′ above. (4′-5′).

PALEOZOIC—Silurian—Burnt Bluff Formation—Byron dolomite

3. Gray, even-bedded, blocky dolomite = unit 12 of the Pottawatomi Point section. (10′).
2. Gray, uneven-bedded dolomite shattering upon weathering into thin wedges = unit 11 of Pottawatomi section. (2′).
1. Gray, blocky dolomite with billowy bedding surfaces that are mud-cracked, ripple-marked and pitted with many tiny depressions that may be raindrop impressions (Fig. 7). This unit, which is equivalent to unit 10 of the Pottawatomi section, extends to water level in Lake Michigan (September, 1934). (5½′).

South shore.—A traverse from the east shore to the Thordarson Camp crossed the highest point on the island and here silicified corals belonging to the Cordell dolomite were found on several high mounds. While only a few feet of the coralline beds were actually seen, because of the heavy growth of trees and underbrush, there must be approximately 40 feet of them in the higher parts of the island. So far as observed, none of the marble-like Racine seems to be present. It is of interest to note here that glacial boulders were found on top of the highest ridge at an elevation of approximately 790 feet above sea level, showing that the glaciers passed over Rock Island.

In the summer of 1934 a long, narrow sand bar extended southward from the Thordarson Camp toward Washington Island, and was separated from a similar extension from the op-

posite shore by a narrow ship channel. This sandy point stood only a foot or so above water level and probably becomes partly submerged when the lake level rises to its average elevation of 581′ A.T. There is a rather broad belt of sand along the entire southern shore of Rock Island as shown on Plate 1. Were water level to drop to 575′ A.T. it is probable that Rock and Washington islands would be connected by a broad sand bar unless the narrow ship channel were deepened and kept open. (Plate 2F).

Detroit Island

Detroit Island lies due south of Washington Island, from which it is separated by shallow Detroit Harbor and to which in times of unusually low water it actually may be attached by sand and gravel bars (Plates 1 and 2F). It is a long, narrow, gravel-bordered, wooded island trending in a northwesterly direction across Secs. 24 and 25, T. 33 N., R. 29 E., and Secs. 30 and 31, T. 33 N., R. 30 E. Its total length is over 3½ miles and its greatest width is about one-half mile. Its total area probably does not exceed 1¼ square miles. The highest point is a rounded knob in the northern half of the island, rising over 70 feet above the water, and there is also a low knob of about 20 feet in height in the southern half (Plate 5). The remainder of the island stands only a few feet above water, is covered by gravel and sand, and passes gently outward under the water to form a shallow platform that extends both eastward and westward for many yards.

Detroit Island is little visited, according to the inhabitants of neighboring Detroit Harbor, because the shallowness of the water around its borders makes landing even a small boat a rather difficult task. If the water level in Lake Michigan were to fall to about 575′ A. T., it is apparent from Plate 2F that Detroit Island would be attached to Washington Island as a long peninsula.

Plum Island

Plum Island lies about midway between the end of Door Peninsula and Detroit Island, and is a low-lying mass of gravel-covered Cordell dolomite about three-fourths of a square mile in area. The elliptical rock core of the island rises slightly more than 30 feet above water and is mantled with glacial and lacus-

trine gravel which supports a good stand of trees. Except along the south shore, the island has a narrow gravel beach, largely composed of dolomite pebbles, cobbles, and boulders and rising from 5 to 10 feet above water level. Inland this gravel is piled against low cliffs of cherty, coralline dolomite rising 10 to 15 feet above the lake. This last relation is well exhibited just south of the Coast Guard Station, near the southeast point of the island, and near the range light in the southwestern corner of the island.

The rock of the island belongs to the fossiliferous part of the Cordell dolomite and is best exposed along the eastern and southern shores where low, undercut cliffs, 10 to 15 feet high, form a ragged shore line. It consists of thin (2″-4″), irregular beds of richly coralline dolomite which alternate with thin bands of chert. Many of the former have their surfaces covered with well preserved specimens of *Favosites, Halysites, Arachnophyllum, Thecia,* and *Heliolites; Syringopora* and *Clathrodictyon* from 6″ to over 24″ across; brachiopods of the genera *Pentamerus* and *Atrypa;* gastropods; and numerous straight-shelled cephalopods. There are some excellent exposures of coralline dolomite about 100 yards south of the Coast Guard buildings. A rapid transit of the middle part of the island showed poor exposures of Cordell coralline beds heavily mantled by gravel and glacial boulders.

Judging from the cobbles that mantle the 10-20 foot rock bench, Plum Island was very likely a small, low-lying island or a shoal area during the later part of the Algonquin and the earlier part of the Nipissing stages. It probably appeared as a small island early in the latter stage (Plate 2D).

Pilot Island

Pilot Island is a small, rocky mass of Racine dolomite lying south of Detroit Island, southeast of Plum Island, and about 3 miles east of the tip of Door Peninsula (Plate 1). The island is elliptical in shape and several hundred yards long. There is a prominent rocky point at the southeastern extremity of the island, and in September, 1934, this could be seen extending under water for several hundred yards to the eastward as a shallow shelf. At the time of the writer's visit the inner part of this point was above water (Fig. 8). A few evergreens help to

set off the six buildings that are present: a lighthouse and five supplementary buildings (Fig. 9).

Pilot island is composed entirely of rock and except for a few small coves has no cobbles along the shore. In a few places, however, there are occasional large boulders of local dolomite and a few glacial cobbles of granite and basalt. The surface of the island is bare except for a few evergreens, but no glacial grooves could be found. The highest point on the island was found to be 12 feet above the lake, or at an elevation of 590′ + A.T. It would appear, therefore, that the waters of early Nipissing time washed across the island, and that the island did not emerge until water level had fallen to around 590′ A.T.

The rock is gray, fairly even-textured, marble-like dolomite which breaks up into great blocks outlined by prominent inclined joints and irregular separation surfaces. It contains the same concentrically ribbed structures that were seen on the south-eastern point of Washington Island and on "The Mountain", and appears to lie at about the same stratigraphic horizon as the rocks at those points do. There is some suggestion of a very gentle southeasterly dip, but the irregularity of the separation surfaces makes this uncertain.

Fish Island and Fisherman Shoal

The recent lake chart of the Washington Island region (U. S. War Dept., Lake Survey, Chart No. 715, *Entrance to Green Bay Lake Michigan,* 1935), with the plane of reference at 578.50 feet above sea level, shows an extensive, northeasterly trending shoal area about three miles off the south-eastern corner of Rock Island. This area, about three miles long and three-fourths of a mile wide, lies less than 30 feet under water and is surrounded on all sides by at least 90 feet of water. It is a submerged, flat-topped pedestal, therefore, and the map shows a tiny island at each extremity.

The northeastern island, named Fish Island on the chart, is surrounded by a flat, submerged platform of about forty acres in area, which is nowhere over 4 feet under water. The south-western island is unnamed but the submerged platform, similar in size and depth to that at the opposite end of the shoal, above which the tiny island rises, is designated Fisherman Shoal.

FIG. 2. Rock fences east of "The Mountain" on Washington Island.

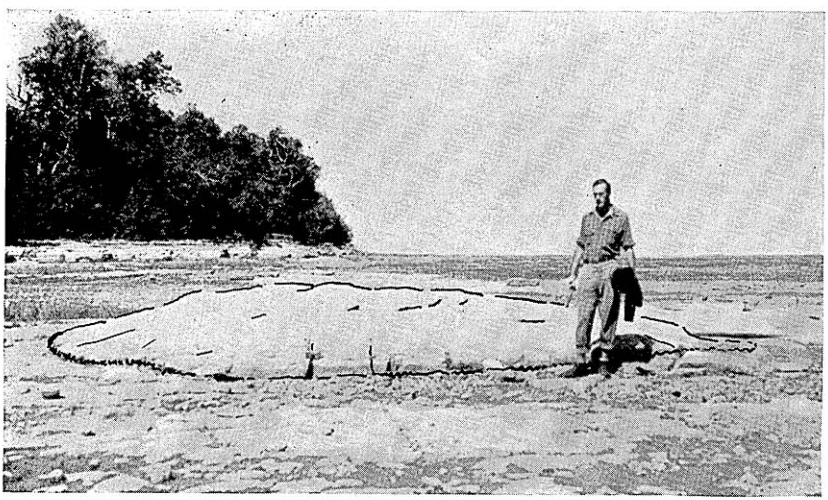

FIG. 3. Reef mound on rocky platform at the northeast corner of Washington Island.

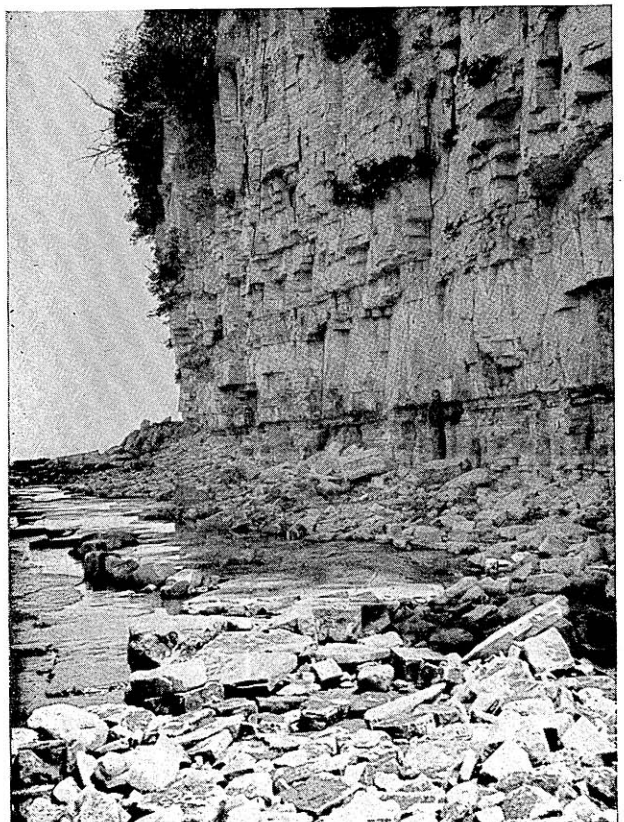

FIG. 4. Profile view of Boyer Bluff.

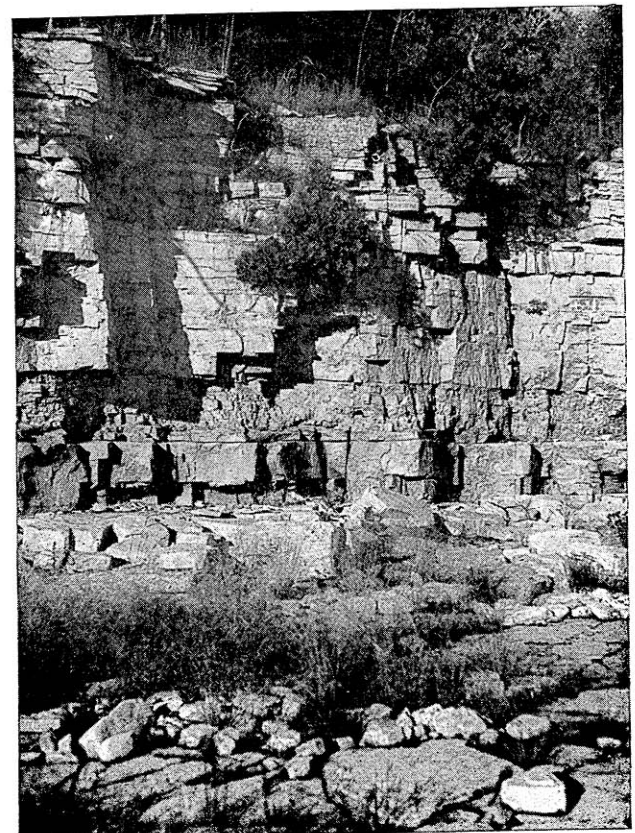

FIG. 5. Low cliff of Byron dolomite near the southeast corner of Rock Island.

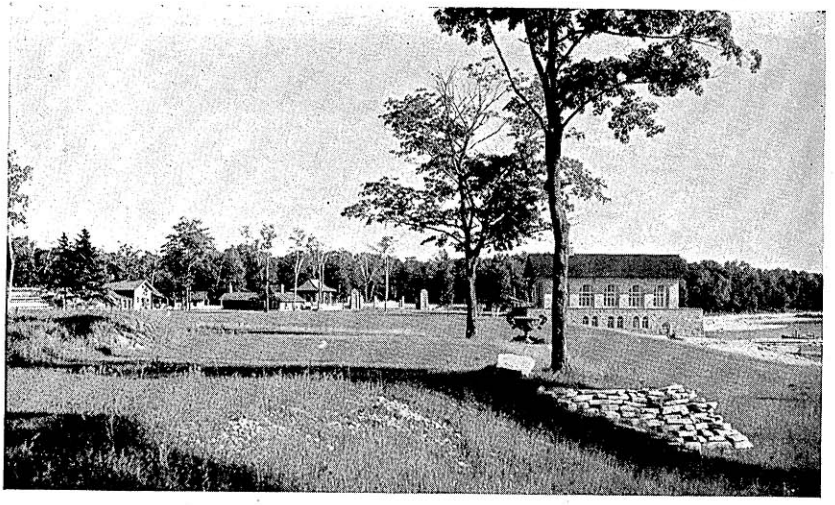

FIG. 6. View of Thordarson Camp, looking south.

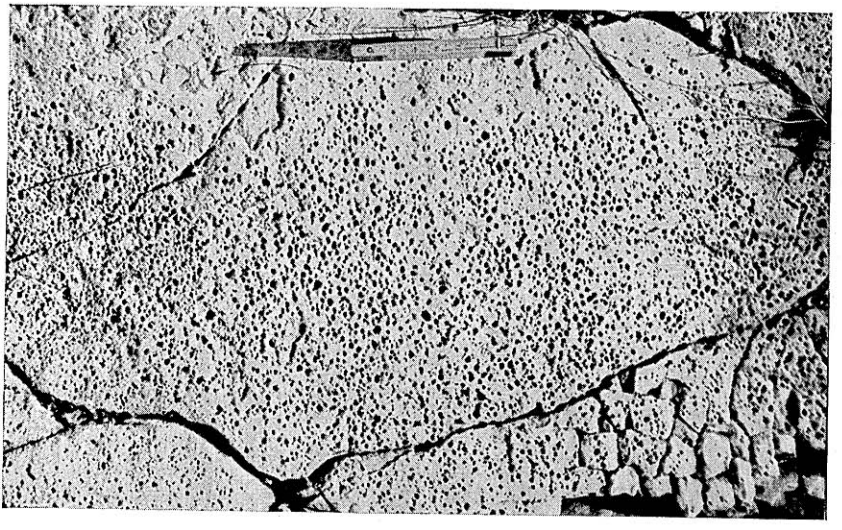

FIG. 7. Pitted bedding surface in the Byron dolomite near the southeast corner of Rock Island.

FIG 8. Rocky eastern shore of Pilot Island.

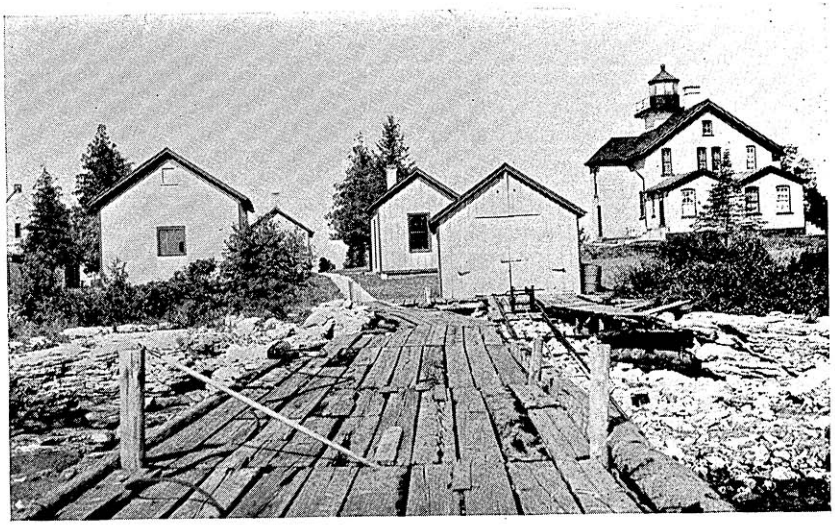

FIG. 9. Lighthouse and adjacent buildings on Pilot Island.

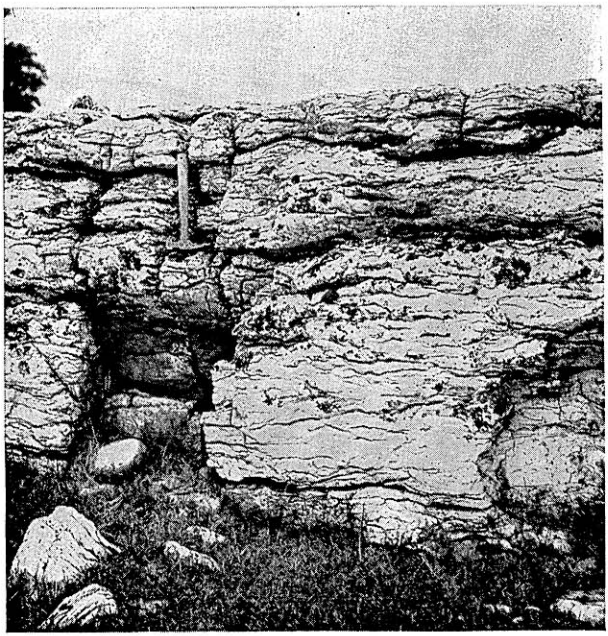

FIG. 10. Weathered Racine dolomite on "The Mountain", Washington Island.

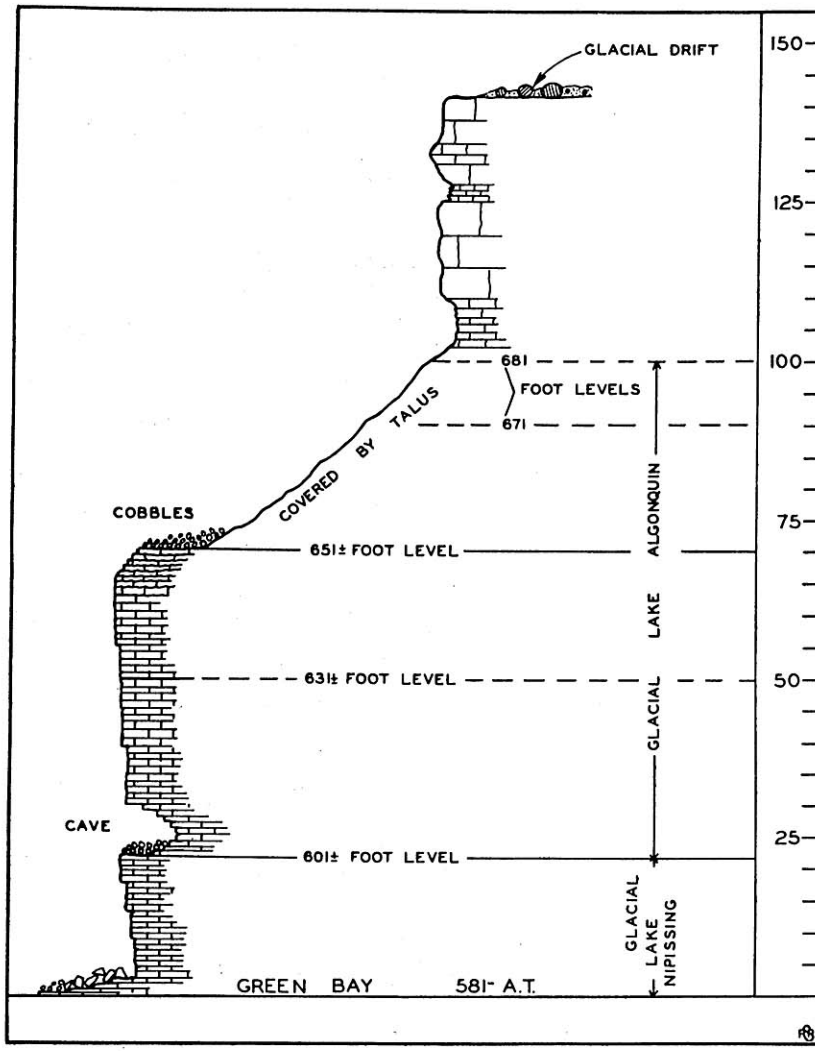

FIG. 11. Diagrammatic geological cross-section of Boyer Bluff.

Fossils Found on the Islands

GENERAL STATEMENT

Well preserved fossils may be obtained at a number of places in the Washington Island region, and since some readers may wish to collect and identify the specimens they collect, a few of the more common genera are illustrated in Fig. 12. In order to determine the different species of a single genus, as for example of *Favosites* which is represented by a number of forms, it will be necessary to consult numerous articles, pamphlets and other sources, but such investigation lies beyond the scope of this brief consideration. Many of the species, however, may be found described and illustrated in Volume 4 of the *Geology of Wisconsin.*

The common genera illustrated in Fig. 12 will be described very briefly so that the amateur collector may have some information about his specimens. Corals are by far the most common of the fossils and will be described first, followed by brachiopods, mollusks, trilobites, and possible plant fossils.

CORALS

1. *Arachnophyllum* (also called *Strombodes*).—This coral consists of large, shallow, five- or six-sided basins, in which the individual organisms sat, bound together into flat, laminar expansions. Some of these colonial masses are a foot or more across.

2. *Cladopora.*—Specimens of this genus look like small twigs or a coarse network of interlacing ribbons with pitted surfaces. An individual organism lived in each of the pits and the entire colony probably looked like a tiny bush on the sea bottom.

3. *Cup corals.*—These small, cornucopia- or horn-shaped corals are common but good specimens are hard to get out of the rock. Most of them are less than 4 inches long. Close examination reveals that the inside of the cone, which usually is filled with hardened mud, is divided into many small compartments by radially directed partitions (these partitions are sometimes called *septa*). The little coral sat on top of the cone and built it and the partitions on the under side of it. Most of the specimens belong to the genus *Zaphrentis.*

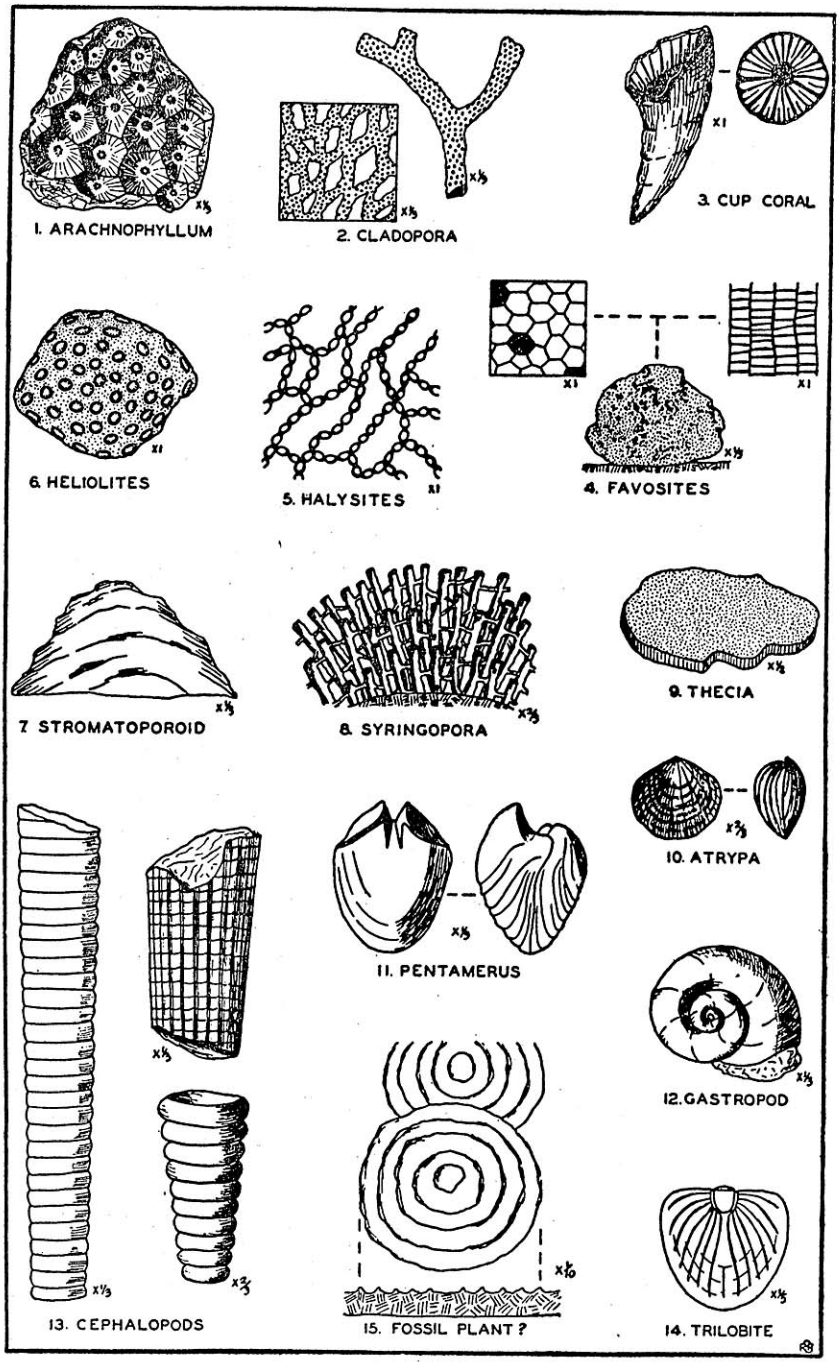

FIG. 12. Fossils found in the Washington Island region.

4. *Favosites.*—This is the well known "honeycomb coral", so named because the colony is made of many five- and six-sided prisms which give it the appearance of a honeycomb. The fossil is often shaped like a cabbage head and is often as much as 6 inches or even a foot across. The individual tubes are divided into many small apartments by transverse floors (sometimes called *tabulae*). In life each tube was occupied by one tiny organism which as it grew upward built one of the little floors under itself.

5. *Halysites.*—This genus has long been called the "chain coral" because, when the colony is seen in cross-section, the small, elliptical tubes in which the organisms lived resemble links in a small chain. The individual tubes are usually from ⅛ to ¼ of an inch across and are arranged much like the posts in a complex stockade or corral. The colonies are usually only a few inches across but in some instances may measure several feet across.

6. *Heliolites.*—This little coral usually occurs as a small nodular head a few inches across, whose surface is pitted with many tiny holes which are really the ends of the tubes in which the organisms lived. In some cases the tubes became filled with material that was more resistant than the coral rock around and so the weathered coral looks as though many tiny pegs had been stuck into it. The pegs will not be connected by cross-bars, however, and this characteristic will help to distinguish it from *Syringopora.*

7. *Stromatoporoids.* These are ancient animals, no longer living, which are believed to have been close relatives of the corals. They built large stony masses shaped like huge cabbage heads, which are composed of many thin laminae arranged in a concentric fashion somewhat like the leaves in a head of cabbage. It is believed that thousands of tiny organisms sat on the surface of a single stony mass and gradually built it upward by precipitating calcium carbonate from the surrounding water. Many of the heads reach a foot or two in greatest dimension, though they more commonly are only inches across.

8. *Syringopora.*—This is the "organ pipe coral", so called because when seen from the side the many little tubes of the

colony have the appearance of pipes in an organ. These tubes may sometimes weather out and then the surface will look like a large pin cushion stuck full of huge needles, except that the tubes will be connected at intervals by tiny cross-bars. Colonies of this genus often attain diameters of several feet.

9. *Thecia.*—Some beds of the Cordell dolomite are covered with small, wafer-like masses which have many pits on their surfaces. These little pits are really the ends of short tubes in which the tiny coral organisms lived. The individuals of this genus built flat colonies, however, instead of the usual domed ones that are so common in most of the other corals that have been described above.

BRACHIOPODS

10. *Atrypa.*—This is a small, double-valued shell an inch or less across, which has an oval shape, with one end somewhat pointed, and a surface covered with numerous, herring-bone ribs or ridges which radiate from the pointed end. The animal that made this shell lived on the inside and attached itself and shell to the sea bottom by the pointed end. These shells are not common and are hard to get out of the rock.

11. *Pentamerus.*—Silicified fillings of this brachiopod shell are quite common in the Schoolcraft dolomite and sparingly in the overlying Cordell beds. These fillings, often composed of white chert, are conspicuous because of their shape and the peculiar structure of the pointed end. In these fossils the original shell has long since disappeared and only the internal filling is left.

MOLLUSKS

12. *Gastropods.*—A few fossil snail shells are scattered through the Schoolcraft and Cordell dolomites, but they are not common and usually can not be removed from the rock with very much success. They are difficult to identify because as a rule they are not well preserved.

13. *Cephalopods.*—Straight-shelled cephalopods are very commonly mistaken for fossilized vertebrae or backbones, or for fossilized snakes, but it should be emphasized that these animals were not yet in existence when the fossil shells were made. The

shell is a long, slowly expanding cone which is divided into a number of compartments by curved, transverse partitions. Usually the shell is seen in longitudinal section, since it will as a rule come to rest in a flat position on the bedding plane, and so the division of the shell into a series of compartments is remindful of vertebrae. In some of the shells there is a complicated structure along the axis and this, in longitudinal section, has the appearance of a string of large beads. As a rule these cephalopod shells can not be specifically or even generically identified with much success except by an expert, hence no generic names will be given here.

TRILOBITES

14. *Goldius.*—Trilobites, which bear some resemblance to crabs and crayfish, have long since died out but they seem to have been present in small numbers during the time that the Racine dolomite was being deposited on the sea bottom, for a few fragments of their shells have been preserved. One of these, *Goldius,* had a large tail piece or "flipper" which is illustrated in Fig. 12. These pieces may be found if diligently sought for in the Racine dolomite at the southeast corner of Washington Island.

Possible Plant Fossils

So far nothing has been said about the peculiar, concentrically ribbed structures that are so common in the Racine dolomite where it outcrops in the Washington Island region. It is believed that these interesting structures may possibly have been formed by lime-secreting, one-celled plants known as algae. These lowly plants are able to precipitate calcium carbonate out of salt waters and build thin layers of the material under themselves, and they may have constructed the fossils that are being discussed, though there is no way of being sure about it.