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The Northern Limits of Glacial Lake Algonquin in Upper Michigan

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A number of ancient shorelines formed by late-Pleistocene proglacial lakes have been found in eastern upper Michigan. These shorelines delimit several water planes, the uppermost of which is correlated with the Main Lake Algonquin stage. This correlation is based on the continuity of the highest water plane with Main Algonquin shorelines in Wisconsin and Ontario, the strength of the shoreline features, its altitudinal relationship with lower water planes, and a reinterpretation of radiocarbon dates from the Sault Ste. Maria area. The isobases of this water plane have a bearing of S75°E. At the time of the maximum extent of Lake Algonquin, ca. 10,600 yr B.P., its northern, ice-limited border lay along the Munising moraine, the northernmost of the two main morainic systems of eastern upper Michigan. This interpretation lends support to the idea of a period of slow deglaciation from ca. 11,000 to 10,000 yr B.P. An ice lobe occupied the central Lake Superior basin until early Holocene time. Radiocarbon dates on wood found beneath till or outwash at several sites indicate a minor ice readvance from the central Lake Superior basin ca. 10,000 yr B.P. If true, this would have prevented the development of the post-Duluth series of glacial lakes in the western Lake Superior basin until ca. 9900 yr B.P., well after the end of the Main Lake Algonquin stage.

INTRODUCTION

The concept of Lake Algonquin as one of the major glacial lakes in the upper Great Lakes region is nearly a century old, having been introduced by J. W. Spencer in 1888. In subsequent years, many geologists, including T. C. Chamberlain, G. K. Gilbert, J. W. Goldthwait, W. H. Hobbs, F. Leverett, and F. B. Taylor, contributed to the development of this concept, primarily through their studies of ancient shorelines. The work of these early students culminated in the synthesis by Leverett and Taylor (1915) in their monograph on the history of the Great Lakes. Their basic outline remained essentially unchanged until Hough (1958) recognized that the waters of Lake Algonquin had been excluded from the Lake Superior basin by glacial ice.

Actual fieldwork on ancient shorelines in the region of upper Michigan where Lake Algonquin is believed to have reached its northernmost extent has been meager. Leverett (1929) described a number of shore features at various localities, but believed that nearly all of eastern upper Michigan had been submerged under Lake Algonquin. Bergquist (1936) mapped many of the shorelines mentioned by Leverett and added some observations of his own. The data of these two workers were used by Hough (1958, pp. 218–222), along with his own correlation of moraines in upper Michigan and nearby Ontario, to support his hypothesis that the northern border of Lake Algonquin is marked by the southernmost of two moraines in eastern upper Michigan. Hough's ideas were modified by Saarnisto (1974, 1975), who believes that Main Lake Algonquin ended before the retreating ice had withdrawn from the Lake Michigan basin. Saarnisto based his interpretations mainly on data from localities near Sault Ste. Marie, Ontario.

The work reported here was undertaken as part of a palynological investigation of the vegetational history of eastern upper Michigan. As an aid in selecting sites for sediment sampling, it was desirable to determine the age and elevation of the water plane of the first glacial lake to cover the region. In light of questions concerning gla-

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cial lake stage chronology and the paucity of observations of ancient shorelines, it was necessary to go to the field for information.

METHODS

Identification of Shore-Related Features

The area chosen for field investigation is that part of upper Michigan lying between the meridians of 84°W and 86°30′W, most of which is between the latitudes of 46°N and 47°N (Figs. 1 and 2). This area comprises most or all of Alger, Schoolcraft, Luce, Chippewa, and Mackinac Counties, and is bordered by Lakes Huron, Michigan, and Superior. A mantle of sandy glacial drift derived primarily from the Precambrian sandstone bedrock underlying the northern third of this region covers most of the area studied. Topographic relief is generally low, but there are several belts of rolling hills that have been identified as moraines (Leverett, 1929; Bergquist, 1936). These "moraines" (Fig. 2), however, consist in large part of outwash plains, many of which are heavily pitted, and other landforms composed of stratified drift. The Niagara escarpment crosses the southern fringe of

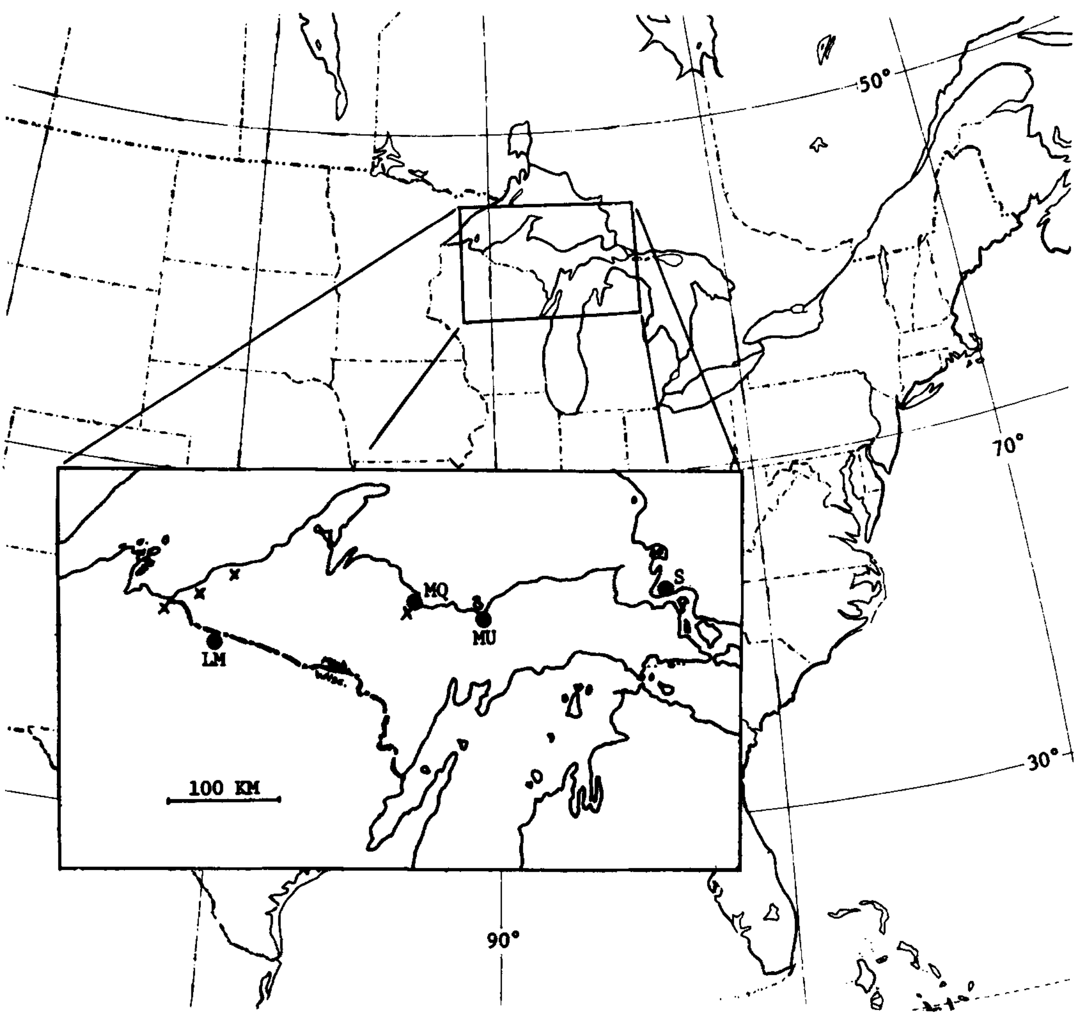

FIG. 1. Map of eastern and central United States showing location of upper Michigan. Inset map shows locations in upper Michigan and northern Wisconsin discussed in text. S= Sault Ste. Marie, Ontario; MU = Munising, Mich.; MQ = Marquette, Mich.; LM = Lake Mary, Vilas Co., Wisc.; X = sites of intradrift wood samples dated at ca. 10,000 yr B.P. (Black, 1976).

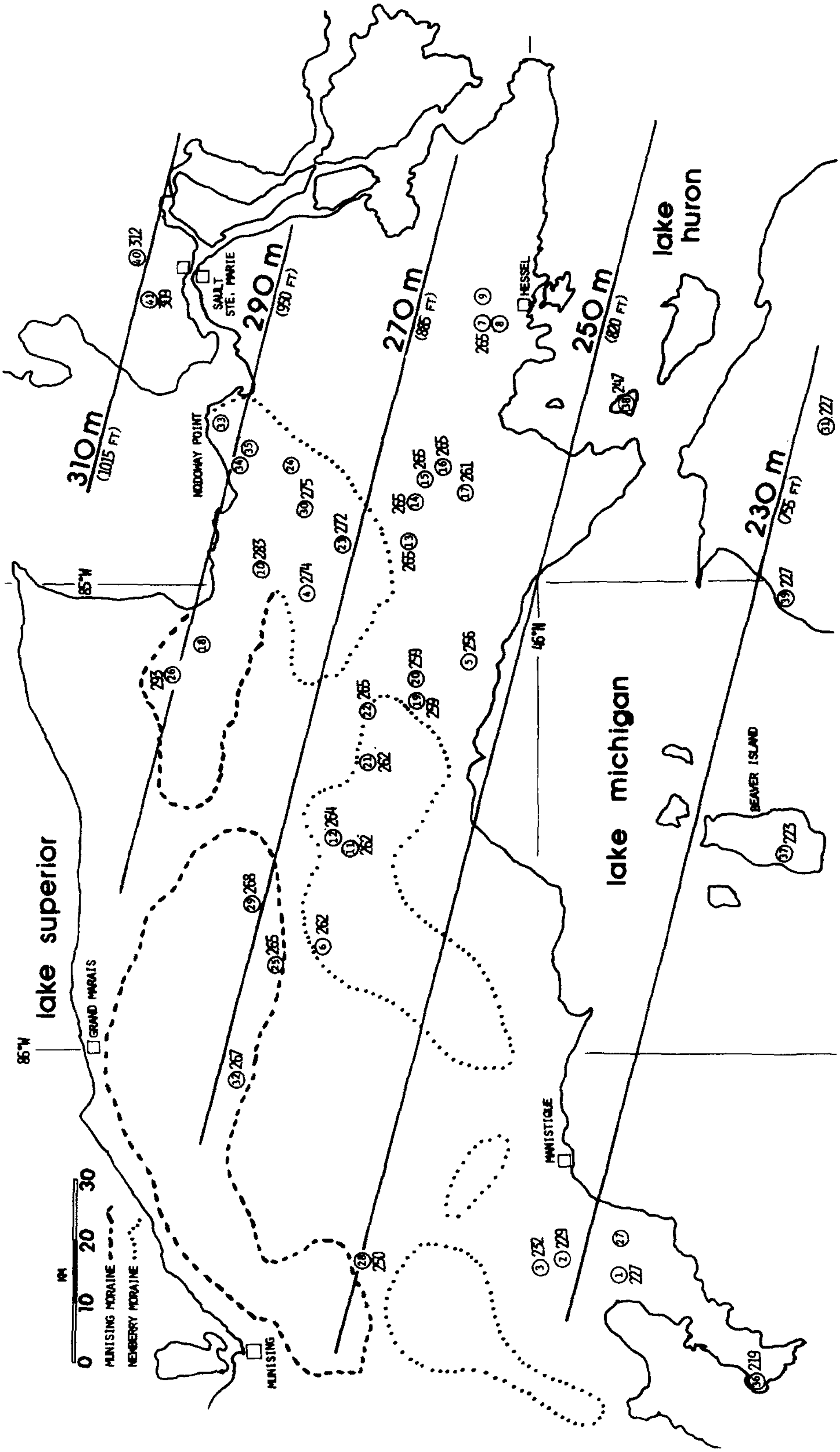

FIG. 2. Map of eastern upper Michigan showing the isobases of the Main Lake Algonquin water plane (elevations in meters above sea level). Numbers in circles indicate sites listed in the Appendix. At sites where shoreline features assigned to Main Lake Algonquin are found, elevations of those features are given. Segments of the Newberry moraine and Munising moraine are outlined by dotted and dashed lines, respectively (modified from Hough, 1958, Fig. 41). Bearing of the isobases is S 75°E.

the region from east to west, but much of it is hidden under glacial drift.

The entire region has been mapped by the U.S. Geological Survey, with coverage in most places by 1:24,000 scale topographic maps with 3-m (10-ft) contour intervals. All topographic maps covering the region were examined to identify landforms indicative of ancient shorelines, such as wave-cut scarps and terraces, beach ridges, bars, spits, deltas, and sand dunes. During the summers of 1978 and 1979 the writer visited sites selected from the maps to determine their validity as shore features. Criteria used in identifying shorelines included continuity and strength of development of the features, co-occurrence of both erosional and depositional features, and the occurrence of features at several elevations at a single site. Shoreline elevations were estimated in the field using topographic map contours as a guide.

In general, the shoreline features are fragmentary and cannot be traced continuously for more than 1 or 2 km. This is mainly due to the fact that at the time of maximum inundation, most of the exposed land area of eastern upper Michigan consisted of many small islands with maximum areas on the order of several square kilometers. Many shorelines, apparently pertaining to lower water planes, can be traced continuously for 10 km or longer. Today, the region is heavily forested, perhaps even more so than when Leverett (1929) published his monograph on the region. As a result, fieldwork here can be difficult and detection of shoreline fragments by ground-level reconnaissance is time-consuming, as would be determination of shoreline elevations by leveling along transects.

In the fieldwork, emphasis was placed on shorelines apparently pertaining to the highest water plane to cover the region, although lower shorelines were examined at many sites. Locations, elevations, and descriptions of shoreline features identified in the field are listed in part A of the Appendix. Elevations of shore cliffs and terraces are taken at the base of the scarp. For beach ridges and spits, elevations are on the crest or uppermost part of the feature. Several outwash plains built out into the proglacial lake and graded to the level of the highest water plane have been recognized. At some places the outer edge of the outwash plain appears to be that of a delta, with an abrupt change in slope in the transition from the flat topset beds to the steeper foreset beds. In such locations (e.g., site 25, Appendix), the elevation given is from the flat topset surface near the outer edge of the delta. Unfortunately, the true deltaic nature of such features could not be confirmed, due to the lack of roadcuts and stream valleys providing adequate exposures of sediment stratigraphy.

Other outwash plains have no definite outer edge; elevations from such sites (e.g., site 32) are from the flat surface of the plain, well away from the point of ice contact. These sites are considered of minor importance as control points in determining the position of ancient water planes. They are given primarily for comparative purposes and because radiocarbon dates have been obtained on basal sediments of small lakes at two of the locations (sites 29 and 30).

Water Plane Reconstruction

To reconstruct the highest ancient water plane to cover the region, the locations and elevations of the observed shoreline fragments were plotted on a map. Also plotted were some previously described Lake Algonquin shorelines located in northern lower Michigan, the Green Bay region of Wisconsin, and the vicinity of Sault Ste. Marie, Ontario. Descriptions of these sites are given in part B of the Appendix. Isobases of water plane deformation were then drawn on the map; an isobase trend of S75°E was determined empirically to be the best fit to the data. Figure 2 is a map of most of the sites listed in the appendix, giving the elevations of features related to the highest water plane and the corresponding isobases. This water plane has been correlated with the Main Algonquin lake stage; the basis of this correlation will be discussed below.

A shoreline diagram is shown in Figure 3. This was constructed by projecting the shorelines from Figure 2 onto a vertical plane perpendicular to the isobases (i.e., bearing N15°E, the direction of maximum tilt). This diagram includes shoreline features pertaining to the highest water plane as well as some of the well-developed features obviously belonging to lower water planes. Different symbols are used for the various types of shoreline features recognized. Features labeled "of indefinite validity" are those which appear likely to be related to lacustrine activity, but which are weakly developed or not totally convincing when examined in the field. Best-fit curves have been drawn (by eye) to represent the highest water plane and four possible lower water planes, designated a, b, c, d, and e. Considering that the elevations of the shore features in Figure 3 are estimated from topographic maps, the elevations of the features and the water planes drawn through them have an accuracy no better than ±2–3 m.

INTERPRETATION OF THE DATA

Extent of the Highest Lake Stage

Upon examination of the features related to the highest ancient water plane that covered eastern upper Michigan, it soon becomes apparent that little dry land stood above the waters of the proglacial lake. All of the shorelines examined in the field are on the higher pieces of ground that were islands forming an archipelago stretching across the region from east to west. Most of the islands were on the order of several square kilometers or less in area; some covered only a few hectares. Many of the islands are on parts of the Newberry moraine, the southernmost of the two main morainic systems that cross the region (Bergquist, 1936). To the north lies the Munising moraine, on which there are fewer shorelines belonging to the uppermost water plane.

Most of the remaining islands are bedrock hills along the higher portions of the Niagara escarpment, the bedrock cuesta that traverses upper Michigan. Examples of these are found at sites 13, 14, 15, 21, and 22. Some of these islands were among the earliest pieces of evidence of Lake Algonquin to be recognized in upper Michigan. Taylor (1895) described the "Munuscong Islands" in the vicinity of Hessel, Mackinac Co. The "Cooks moraine" in Schoolcraft Co. (Bergquist, 1936, pp. 68–69), and Burnt Bluff in Delta Co. (Hobbs, 1911; Prahl and Farrand, 1968) are also former islands on the escarpment. Scattered throughout the region are many such islands, their slopes commonly displaying a series of shorelines at different elevations. One of the most impressive localities is the north side of Maple Hill (site 15), where there are sheer, wave-cut dolomite cliffs marking the highest water plane, a series of lower beach ridges, and a large sand and gravel spit.

The distribution of the shorelines suggests that at the end of the highest lake stage the margin of the continental ice sheet lay along the Munising moraine, the northern of the two morainic systems. The south side of this moraine is bordered by large outwash aprons that apparently were deposited into that lake and graded to its level. Sites 25, 28, 29, 30, and 32 on Figure 3 show the relationship between the outwash plains and the highest water plane. It is difficult to determine the exact elevation of the lake level to which these outwash aprons are adjusted, for most of these sites were probably shallowly submerged, but they appear more likely to be related to water plane a than to water plane b.

As mentioned earlier, the outer edges of some of these aprons have a deltaic morphology. The place where the upper reaches of the Tahquamenon River cross the edge of one such outwash apron (site

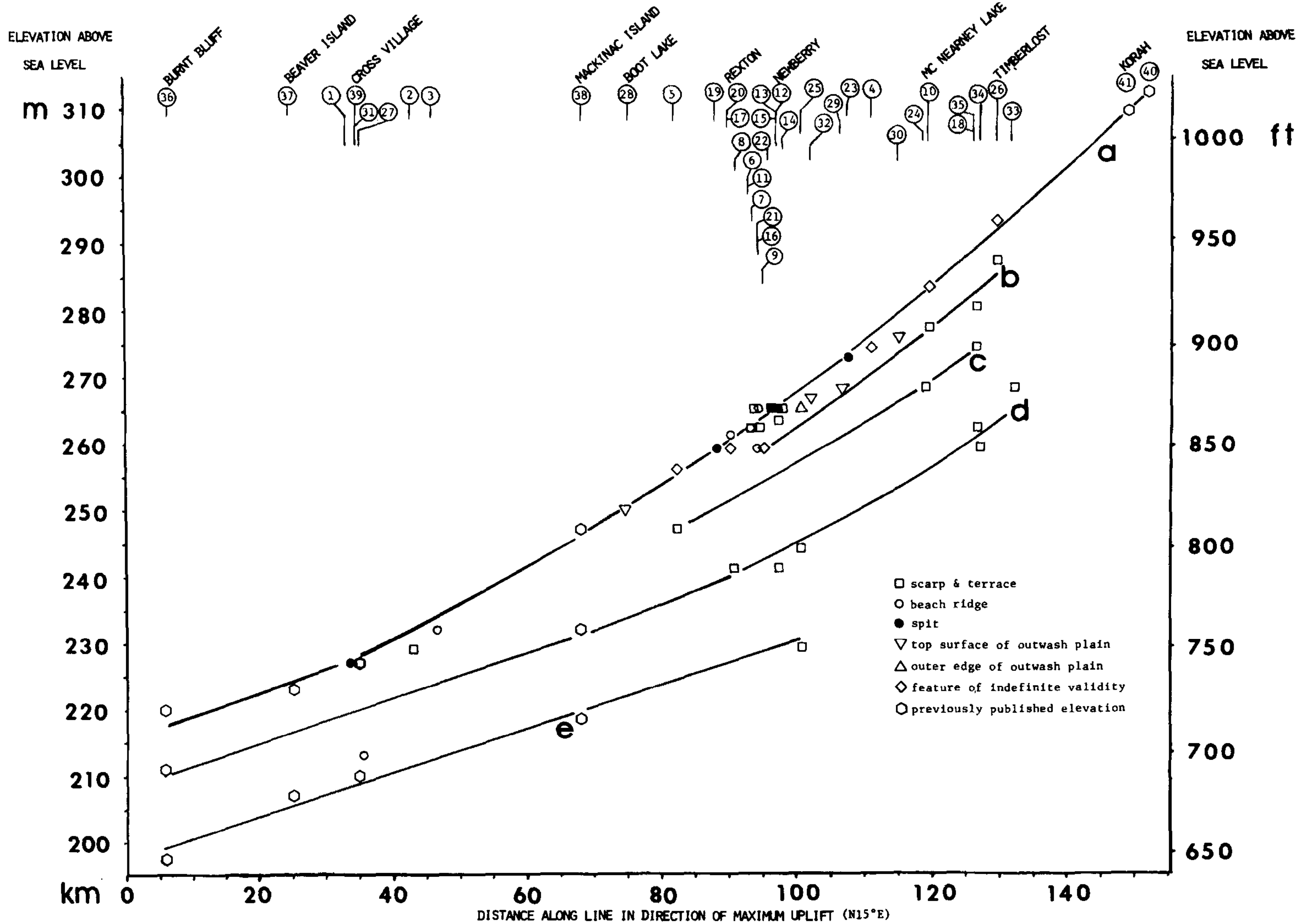

FIG 3. Profile of glacial lake water planes in eastern upper Michigan. Shorelines are projected onto a plane bearing N15°E. Numbers in circles and associated lines indicate positions of shore feature sites (see Appendix). Water plane a is correlated with the Main Lake Algonquin level, water plane d with the lowest member of the Algonquin "upper group," and water plane e with the Battlefield level.

25) is reminiscent of a cuspate delta. It is possible that this section of the river occupies one of the major outwash channels that drained from the ice front. A similar situation may exist along the upper reaches of the east branch of the Fox River, about 8 km north of Seney, Schoolcraft Co. The Boot Lake outwash plain (site 28) is an outwash plain segment graded to the level of the highest lake stage; it was isolated later by wave action and/or fluvial erosion associated with a lower lake stage (cf. Bergquist, 1936, p. 85). Fluvial and shoreline terraces related to lower lake stages are also apparent at the Tahquamenon River and Fox River localities.

Also consistent with the idea that the ice border of the highest lake stage was along the Munising moraine is the lack of wave-cut scarps and terraces, beach ridges, and other strandline features on this moraine that would correspond to water plane a. In a few places on the north slope of the Munising moraine (e.g., sites 10 and 26) there are weakly developed features at the highest lake level.

Strength of Development of the Shorelines

When viewed in the field, it is clear that the uppermost shorelines were formed by a lake that lasted for a longer time than most of the subsequent lake levels. In places where a number of shore features at different elevations occur, the features pertaining to the highest water plane are usually the most strongly developed (e.g., site 15). Large depositional features, such as spits, are almost exclusively associated with the highest lake level (e.g., sites 1, 13, and 23).

This is similar to the situation seen in other parts of the Lake Huron and Lake Michigan regions where the shorelines of Main Lake Algonquin are found. The strength of Main Algonquin shore features is due in part to the length of time, several hundred years, that this stage existed. Another factor is the transgressive nature of the waters of Early Lake Algonquin. Between at least 11,500 and 11,200 yr B.P. Lake Algonquin drained via the Kirkfield outlet (Karrow *et al.*, 1975), which was undergoing isostatic rebound. Therefore, even though much of the Lake Algonquin region was rising isostatically, the large part of the basin south of the isobase of Kirkfield, ca. 260 m elevation (Deane, 1950), experienced rising water levels for a long period. When the lake had risen high enough to drain through the Port Huron outlet, the Main Lake Algonquin stage, which lasted about 500 yr was established.

Shoreline Diagrams and Isobases

The shoreline diagram (Fig. 3) shows that a number of previously described Main Lake Algonquin shorelines, such as those at Beaver Island, Korah, and Mackinac Island, fit well on curve a, the highest ancient water plane in eastern upper Michigan. In Figure 4 this shoreline profile is extended to the southwest to include the Main Algonquin shorelines around Green Bay described by Goldthwait (1907). We can now draw a reasonably smooth continuous curve from the Algonquin shorelines in the region of horizontality (i.e., unaffected by isostatic uplift), across upper Michigan, to the vicinity of Sault Ste. Marie, Ontario. This is good evidence that water plane a (Fig. 3) pertains to Main Lake Algonquin. Water plane a of Figure 4 is very similar to the Algonquin water plane shown in Plates XXIII and XXIV of Leverett and Taylor (1915), with the exception that the void in the curve over upper Michigan is now filled, but at a somewhat lower elevation than indicated by the earlier authors.

Goldthwait (1910, Plate 5) was the first to draw isobases for the Lake Algonquin water plane, using data from some 100 localities in Ontario, Wisconsin, and Michigan (but including only 3 sites in upper Michigan). Rather than protraying the isobases as parallel lines, as is common in more recent depictions (cf. Leverett and Taylor, 1915, Fig. 8; Hough, 1958, Fig. 42), Goldthwait draws them as concentric

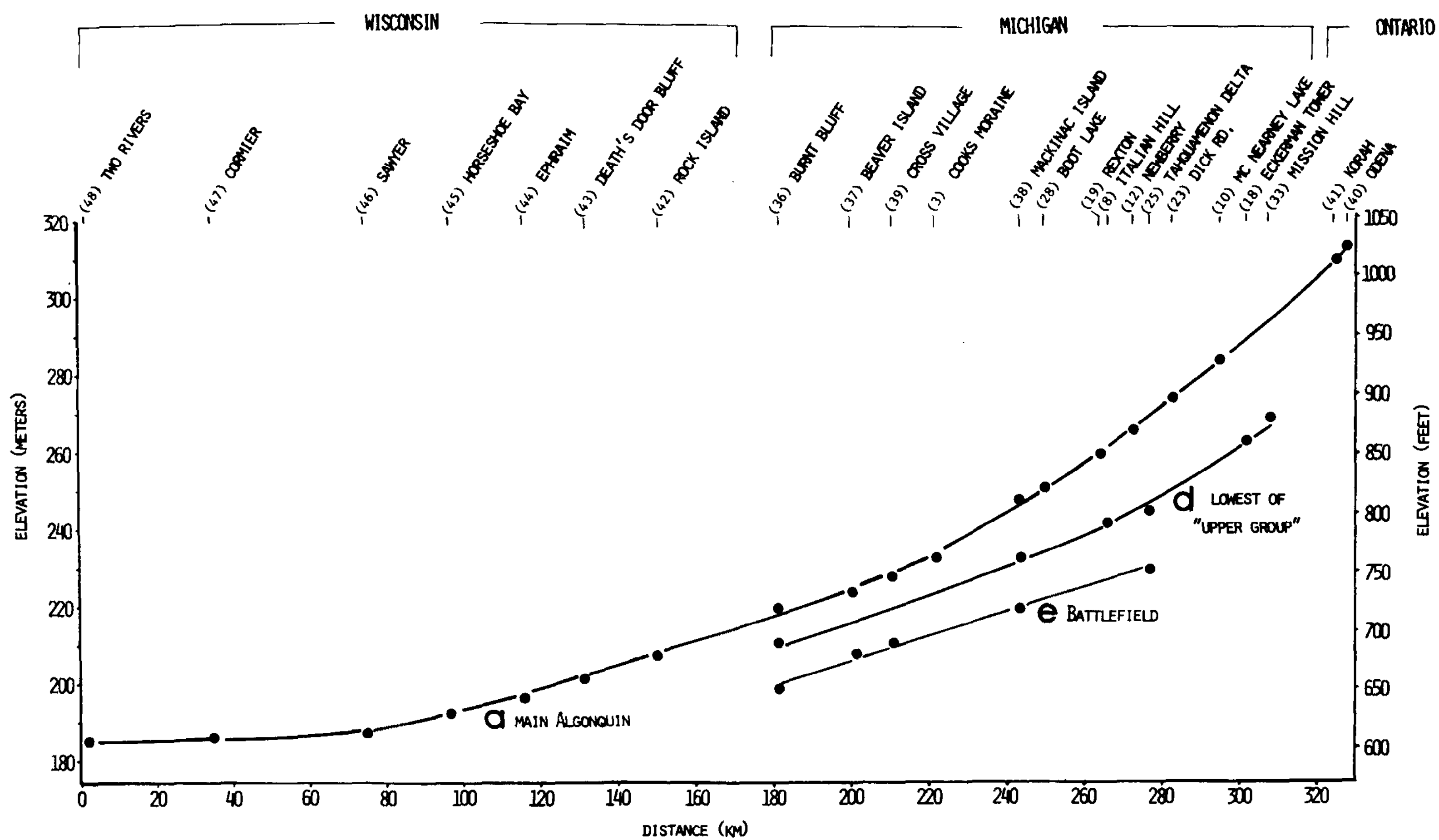

FIG. 4. Profile of water planes of the Main Algonquin, lowest member of the Algonquin "upper group," and the Battlefield stages. The Main Algonquin water plane is here extended from upper Michigan and adjacent Ontario (see Fig. 3) to the region of horizontality in northeastern Wisconsin. See Appendix for details on each site indicated. Shorelines are projected onto a plane bearing N15°E.

curves. In the Lake Huron region Goldthwait's isobases have a trend of about S69°E, while in the Lake Michigan region the trend is S75°E. The isobase trend of S75°E determined for eastern upper Michigan (Fig. 1) is in full agreement with the trend of the isobases to the south, over Lake Michigan.

There is reason to believe that curved rather than straight isobase lines would render a more accurate representation of the Algonquin water plane even in an area the size of that shown in Figure 2. If only the upper Michigan shoreline data from the area east of the 85°30′W meridian are plotted on a shoreline diagram, it will be found that the isobase trend appears to be somewhat closer to S70°E than to S75°E. However, if points farther west are plotted on the same diagram, they will not fit well on the water planes described by the points to the east. Close examination of the data will show that some of the vertical scatter of the points plotted on Figures 3 and 4 (e.g., at Burnt Bluff) can be ascribed to the fact that the isobase trend is not uniform throughout the region under consideration. Therefore, the trend of S75°E shown on Figure 2 must be considered only as a regional average in upper Michigan. No attempt was made to portray curved isobases on Figure 2 because they would imply greater accuracy than the data permit.

Slope of the Water Plane

The slope of water plane a (Fig. 3) increases steadily as it is traced to the northeast. Within the 232- to 265-m (760- to 870-ft) isobase interval the average slope is 0.61 m/km (3.2 ft/mile). It increases to 0.92 m/km (4.9 ft/mile) in the 277- to 309-m (910- to 1015-ft) isobase interval.

These figures compare well with the slope of the Main Lake Algonquin water plane seen in other localities, such as on the east side of Lake Huron (Deane, 1950, Fig. 7). However, use of such a comparison between widely separated localities is probably not a valid means of shoreline correlation. It is possible that Main Algonquin water plane slopes may not be uniform throughout the upper Great Lakes region on account of differences in ice thickness, rates of deglaciation, and other variables affecting the rate and magnitude of isostatic readjustment.

Lower Shorelines

It may be argued that water plane a (Fig. 3) may correspond to one of the Algonquin "upper group" shorelines of Leverett and Taylor (1915, pp. 416–433) and not to the Main Lake Algonquin stage, in light of the margin for error of ±2–3 m on the position of this plane. As an aid in clarifying the status of water plane a, some of the more strongly developed shore features belonging to lower lake stages have been plotted on Figure 3. By no means do these represent all of the lower shorelines observed on the topographic maps or in the field. They are plotted mainly to show that lower water planes are detectable.

Curve b of Figure 3 represents a number of relatively strong shoreline features in eastern upper Michigan, some of which can be traced continuously for 5 km or more. These include the highest well-developed shorelines on the north-facing (ice-contact) slopes of the more eastern segments of the Munising moraine. Apparently, this shoreline marks a glacial lake level attained shortly before or soon after the ice withdrew from these segments of the Munising moraine. In a number of localities shorelines on curve b are found close to shorelines pertaining to curve a and are usually about 5 m lower in elevation than the latter. Correlation of this water plane with the highest member of the post-Main Algonquin upper group of beaches may not be unreasonable.

It is difficult to make a judgment on the validity of curve c, as it is defined only on the basis of three sites. Two of the sites (24 and 35) are on opposite ends of a shoreline fragment which is traceable for 8 km. The water plane slope between these two sites is

0.79 m/km (4.2 ft/mile), as compared to the 0.92 m/km (4.9 ft/mile) slope of curve a in the same region.

Many of the shorelines on curve d are also rather strongly developed and are continuous over several kilometers. This curve, particularly the segment below 245 m elevation, coincides with the water plane of the lowest shoreline of the Algonquin upper group as described by Leverett and Taylor (1915, Plate XXIII).

All but one of the points defining water plane e are previously described shorelines correlated with the Battlefield shoreline of Leverett and Taylor (1915, pp. 433–436). Hough (1958, p. 231) considers the Battlefield level to be equivalent to the Wyebridge stage of the Lake Huron region. In Ontario the Wyebridge shoreline has been found 28 to 38 m (95 to 125 ft) below the Main Algonquin level (Harrison, 1972). On Figure 3, curve e varies from 19 to 37 m (62 to 121 ft) below the Main Algonquin level. While this water plane in upper Michigan compares well with the data on the Wyebridge of Ontario, definite proof of their synchronous development is lacking. Therefore, the older name, Battlefield, seems more appropriate for the level represented by curve e.

In summary, on Figure 4 are indicated the three ancient water planes in eastern upper Michigan that can be identified with a reasonable degree of confidence. These are the Main Lake Algonquin level, the lowest member of the Algonquin upper group, and the Battlefield level, corresponding to curves a, d, and e, respectively, of Figures 3 and 4. Principal among the reasons for assigning these correlations is the fact that each curve includes points previously identified with these stages.

CONFLICTS WITH PREVIOUS INTERPRETATIONS

The Extent of Main Lake Algonquin in Upper Michigan

A number of the upper Michigan shorelines described in the Appendix have been observed previously by workers such as Leverett (1929) and Bergquist (1936), but interpreted in a different way by them and subsequent students. An effort will be made here to resolve some of these differences.

Leverett (1929, p. 67) mentions shorelines at elevations between 262 and 265 m (860 and 870 ft) on the Newberry moraine just south of McMillan, in Luce Co. On the basis of his water plane calculations, which included supposed Algonquin shorelines all around Lake Superior, he judged that these shorelines were about 9 m too low to have been formed by Main Lake Algonquin. He supported this by citing the observation of shorelines at about 274 m (900 ft) near Rexton, Mackinac Co., 40 km southeast of McMillan. Leverett explained the lack of a shoreline near McMillan at the proper elevation, which he estimated to be somewhere above 274 m, by postulating the existence of stagnant ice in that locality until after the lowering of lake levels from the Main Algonquin level. This explanation was later adopted by Bergquist (1936, p. 95).

Hough (1958, pp. 216–223) has shown that Lake Algonquin did not extend into the Lake Superior basin, as Leverett had believed. His primary evidence is from glaciofluvial deltas graded to the Algonquin level, north of Sault Ste. Marie, Ontario (e.g., sites 40 and 41). He extended the ice-margin position marked by these deltas to the southwest, into upper Michigan, and correlated it with the Newberry moraine. Hough made this correlation because he interpreted Leverett's discussion on stagnant ice at McMillan to mean that the waters of Lake Algonquin lay against the ice at the time of the emplacement of the Newberry moraine, and that the waters fell to a lower level before the ice retreated to the Munising moraine. Such reasoning is flawed, however, for the concept of the change in water level before the deglaciation of McMillan has its basis in the belief that the elevation of the Algonquin water plane in this vicinity was ca. 275 m. This, in turn, depends on the existence of Algonquin shorelines around the Lake Superior basin, which is the very thing that Hough intended to disprove.

According to the interpretation presented here, the 262-m shoreline near McMillan falls exactly on water plane a, the Main Algonquin water plane (Fig. 3, site 6). On the south flank of the Munising moraine, 6 km north of McMillan, is the edge of an outwash apron that is graded to the level of water plane a. There is no evidence for a higher water plane, either to the north, or to the south. The present writer has searched in vain for Leverett's 274-m shoreline at Rexton. The highest shoreline in this vicinity appears to be at 259 m (sites 19 and 20); it also lies on water plane a. In fact, there is very little ground near Rexton that even reaches 274 m. There is a good possibility that the elevation cited by Leverett is an erroneous aneroid determination.

This interpretation of an Algonquin water plane somewhat lower than determined by Leverett also resolves some of the conflict he had in explaining why moraines that were supposedly submerged had strong morainic features not muted by wave erosion (Leverett, 1929, p. 49).

As stated earlier, the inner, or Munising moraine appears to delimit the northern boundary of the highest water plane to cover eastern upper Michigan, here correlated with Main Lake Algonquin. This position is still compatible with that of the deltas north of Sault Ste. Marie, for the point where Hough connects the latter with the Newberry moraine, at Nodoway Point, is also the locality where the Munising moraine merges with the Newberry moraine (cf. Hough, 1958, Fig. 41). One effect of this change in morainic correlation is to decrease the depth of the reentrant occupied by Lake Algonquin in the Sault Ste. Marie area.

Hough's interpretation of the ice front position north of Sault Ste. Marie has been challenged by Cowan (1976), who places the ice northeast of the line drawn by Hough near Goulais Bay, rather than to the southwest. This interpretation implies that Main Lake Algonquin extended into at least part of Whitefish Bay (i.e., that part of Lake Superior immediately north of Nodoway Point, Fig. 2). Support for this possibility may be found in the fact that weakly developed shorelines apparently corresponding to Main Lake Algonquin are found at two sites (10 and 26) on the north-facing slopes of the segment of the Munising moraine nearest to Whitefish Bay. If Cowan's interpretation is correct, the northern limit of Main Lake Algonquin may have lain to the north of the Munising moraine, or at least its easternmost segment.

Correlation of Shorelines in the Sault Ste. Marie Area

More recently, Saarnisto (1974, 1975) has introduced another interpretation of the deglaciation of upper Michigan. His ice front correlation essentially follows that of Hough (1958). However, he states that the lake that bordered the ice when it stood at the Newberry moraine was the first *post*-Main Algonquin stage, which had an outlet via the South River in the Algonquin highland (Saarnisto, 1974, p. 320). Saarnisto's reason for this correlation is that "the Main Algonquin beaches east of Lake Huron (Chapman, 1954) at corresponding isobases are up to 20 m higher . . ." than the deltas near Sault Ste. Marie (Saarnisto, 1974). Prest (1970, p. 728) makes a similar statement correlating the highest strandlines near Sault Ste. Marie with one on Manitoulin Island at 309 m (1013 ft), which he says falls *25 ft* (8 m) below the Main Algonquin shoreline when projected to the east side of Lake Huron.

In either case, a correlation based on such long-distance projection of shoreline elevations, over 200 km in this instance, is highly tenuous. When considered in light of the fact that the isobases along which such projections should be made are curved and not straight, it is not surprising that the projections of Saarnisto and Prest were off by up to 20 m.

Identification of the highest deltas north of Sault Ste. Marie with the post-Main Algonquin lake stage draining via the South River is highly unlikely. Harrison (1972, p. 29) states that the South River outlet was first used by Glacial Lake Wyebridge. If curve e of Figures 3 and 4 corresponds to the Wyebridge water plane, on the basis of Hough's (1958) correlation with the Battlefield level, then the deltas north of Sault Ste. Marie almost certainly do not belong to the Wyebridge stage.

Radiocarbon dates from the Sault Ste. Marie area are used by Saarnisto (1974) to further support his correlation of these deltas with a post-Main Algonquin lake. Bottom sediments of Upper Twin Lake and Prince Lake, both about 18 km west of Sault Ste. Marie, Ontario, yielded radiocarbon dates of 10,650 ± 265 yr B.P. (Hel-400) and 10,800 ± 360 yr B.P. (GSC-1715), respectively. Saarnisto (1974, p. 330) considers the 10,650 ± 265 yr B.P. date to be a minimum date for the time of the drop of lake level from the highest glacial lake shorelines in the Sault Ste. Marie area, and the isolation of the Upper Twin Lake basin from the glacial lake. Upper Twin Lake lies 5 m below the highest shoreline. Using a date of about 11,000 yr B.P. for the end of the Main Lake Algonquin stage, estimated using radiocarbon dates from the northern Lake Huron area and the Two Creeks forest bed, Saarnisto places the first post-Main Algonquin stage between 11,000 and 10,650 yr B.P.

However, more recent studies of radiocarbon dates and pollen stratigraphies from the southern Lake Huron basin place the draining of Main Lake Algonquin shortly after 10,600 yr B.P. (Karrow *et al.*, 1975). If the 10,650 yr B.P. date from Upper Twin Lake does approximate the end of the highest glacial lake level in the Sault Ste. Marie area, then a correlation of that level with the Main Lake Algonquin stage would be a suitable reinterpretation of Saarnisto's data. Since the highest water plane in the Sault Ste. Marie region is the same as in eastern upper Michigan, this lends further support to the correlation of water plane a (Figs. 3 and 4) with Main Lake Algonquin.

Cowan (1976) also correlates the highest lake level at Sault Ste. Marie with the Main Algonquin stage, primarily on the basis on the degree of development of the shoreline north of the city.

Radiocarbon Dates from Eastern Upper Michigan

The present writer has also sought evidence on the age of the highest glacial lake in eastern upper Michigan. To this end, bottommost organic sediments from a number of small lakes have been radiocarbon dated. Two of the lakes, Wolverine Lake (site 29) and East Soldier Lake (site 30), are kettle-hole lakes situated on outwash plains deposited into the highest glacial lake. The former site is on the Munising moraine and the latter is on the Newberry moraine (Fig. 2). At Wolverine Lake the bottom sediments are dated at 9980 ± 135 yr B.P. (Beta-1288) and at East Soldier Lake the date obtained is 8185 ± 95 yr B.P. (Beta-1287).[1] Apparently, the beginning of organic sedimentation in these lakes was delayed several hundred years by the slow melting of the ice-blocks that formed the depressions. Therefore, it is unlikely that either of these dates relates directly to the age of any glacial lake stage. Unfortunately, in eastern upper Michigan there is a lack of small bedrock-basin lakes that could be used for a study of lake chronology as done by Saarnisto (1974, 1975). It may be of interest to note, however, that Wolverine Lake has the oldest bottom sediments of five small lakes sampled in eastern upper Michigan.

DEGLACIATION CHRONOLOGY AND CLIMATE

The Late Pleistocene

Using the information presented here, we

[1] Further radiocarbon dating and analysis of the pollen stratigraphy of the East Soldier Lake sediment core indicate this date to be anomalous. It is estimated that the lowermost organic sediments in this core date from between 9500 and 9000 yr B.P.

can now revise the scenario for the deglaciation of eastern upper Michigan. The final deglaciation of this region began soon after the peak of the Greatlakean ice advance at ca. 11,500 yr B.P. As the ice retreated from the Lake Michigan basin, Main Lake Algonquin expanded northward, covering much of eastern upper Michigan. The first halt in the position of the ice front is marked by the Newberry moraine. After a short period of retreat, the ice border stopped again, building an inner moraine, the Munising moraine. The ice remained along the Munising moraine for a relatively long time, possibly several centuries. Evidence for this is the large size of the moraine and its large outwash aprons deposited into Lake Algonquin. One such apron, the Kingston plain of Schoolcraft and Luce Counties, covers several hundred square miles (Bergquist, 1936, p. 86). The strength of the Main Algonquin strandlines just south of the ice also attests to the great length of time that the area was inundated. It is possible that the ice retreated from some parts of the Munising moraine shortly before the end of the main Algonquin stage at ca. 10,600 yr B.P.

Saarnisto (1974) recognized the time interval from 11,000 to about 10,100 yr B.P., during part of which time the Newberry and Munising moraines were emplaced, as a period of cold climate. This he calls the "Algonquin Stadial" and correlates it with the Younger Dryas Stadial of Europe. A manifestation of this postulated cold climate was the slow deglaciation of the Algonquin highlands of Ontario, which controlled the opening of successively lower outlet channels for the post-Algonquin lakes in the Huron–Michigan basin. The earliest pollen zones from Upper Twin Lake and Prince Lake near Sault Ste. Marie contain a large component of nonarboreal pollen, attributed by Saarnisto (1974) to tundra vegetation resulting from the cold climate.

An Early-Holocene Ice Readvance

Additional evidence which may possibly support the hypothetical Algonquin Stadial comes from the Lake Superior shore of central upper Michigan. J. D. Hughes (personal communication, 1980) reports the discovery in 1976 of a buried forest bed in the vicinity of Lake Gribben, 16 km southwest of Marquette. A forest of white spruce and possibly larch was buried *in situ* within an outwash apron of the outer Marquette moraine, a correlative of the Munising moraine. The trees were buried in up to 3 m of rhythmically banded lacustrine clays, silt, and fine sand, above which there is up to 3 m of crossbedded gravel, followed by medium crossbedded sand 2–4 m upward to the ground surface. It is interpreted that the trees were killed by local proglacial ponding and burial with lacustrine sediments. Subsequent deposition of the outwash gravels and sands eroded away most of the upper parts of the trees. There is no evidence that the ice sheet itself readvanced over the forest site.

Some of the trees from the buried forest have over 150 growth rings. Radiocarbon dates from the outer parts of two trees are 9780 ± 250 yr B.P. (W-3904) and 9850 ± 300 yr B.P. (W-3866); spruce needles from the organic horizon of the paleosol in which the trees were rooted were dated at 10,230 ± 300 yr B.P. (W-3896). Two additional dates of 10,220 ± 215 yr B.P. (DAL-338) and 9545 ± 225 yr B.P. (DAL-340) have been obtained; the mean of the five dates from the site is 9925 yr B.P.

Similar dates between 9730 ± 140 yr B.P. (I-5082) and 10,420 ± 220 yr B.P. (OX-1) on wood embedded in till at sites on the south side of Lake Superior in northern Wisconsin and western upper Michigan have been reported (Black, 1976, p. 110; Fig. 1).

Hughes proposes the name Gribben Interstadial for the period of at least 150 yr during which the buried forest was growing, and the name Marquette Stadial for the succeeding period of inferred ice advance that climaxed slightly less than 10,000 yr B.P. The ice advance envisioned by Hughes originated in the central Lake Superior basin. At its maximum extent during the Marquette Stadial, the ice covered the northern fringe of central and western upper Michigan and northern Wisconsin, within several dozen kilometers of the south shore of Lake Superior. The exact magnitude of the distance that the ice may have readvanced has not been estimated.

Saarnisto's Algonquin Stadial and Hughes' Gribben Interstadial are roughly overlapping in time. The existence of the forest near Marquette ca. 10,100 yr B.P. agrees with the spruce forest interpreted by Saarnisto (1974) from the pollen stratigraphies of Upper Twin Lake and Prince Lake near Sault Ste. Marie.

W. J. Merry (personal communication, 1980) has noted that during the last two decades of their lives, the trees at the Gribben forest site experienced retarded growth, indicated by a decrease in the width of their growth rings. Merry proposes that this indicates a climatic deterioration at the initiation of the Marquette Stadial.

A possible climatic fluctuation at the Pleistocene–Holocene boundary has been observed by Webb (1974, pp. 24–27) in pollen diagrams from four lakes and bogs in western upper Michigan and adjacent northern Wisconsin. The lowest portions of the pollen stratigraphies from these sites (Webb, 1974, Fig. 8) show an initial period of spruce dominance (50–80% of total pollen) which declines abruptly by ca. 20%, accompanied by a corresponding increase of pine pollen to 30–50%. The decline in spruce is short-lived and spruce pollen percentages return to near their former values as quickly as they had declined, while pine decreases to its former value of 20–40%. This recovery also is brief, and spruce undergoes a final decline to less than 10% and pine becomes dominant at 60% or greater. Climatically, this sequence may indicate an initial cool climate (spruce dominance), a short warm period (spruce decline, rise in pine), a return to cooler conditions (short peak of spruce dominance), and a final warming at the beginning of the postglacial (complete decline of spruce, pine becomes dominant).

The portion of the sediment core from Lake Mary, Vilas Co., Wisconsin, pertaining to the final decline of spruce is dated at 9460 ± 100 yr B.P. (WIS-371, Webb, 1974). Just prior to this is the early Holocene peak of spruce, estimated by Webb to be at 9800 yr B.P. If this estimate for the age of the spruce peak is correct, then it would be contemporary with the Marquette Stadial, and the preceding short period of spruce decline and increase of pine may correspond to the Gribben Interstadial. All four of the lake and bog sites having a pollen record showing this fluctuation in spruce and pine are within 60 km of localities where intratill wood of an age corresponding to the Gribben Interstadial have been found (Fig. 1). Unfortunately, Lake Mary is the only one of these pollen sites which has been radiocarbon dated.

Such a correlation between an ice advance and a fluctuation in the pollen record has never been proven within the Great Lakes region (Wright, 1976). It has been suggested that large-scale ice fluctuations, such as the Greatlakean (Valderan) readvance, which have no corresponding vegetational changes may have been the result of nonclimatic glacial surging or changes in snow accumulation away from the ice border. If the correlation of pollen assemblage fluctuations at Lake Mary and other sites with the relatively minor Marquette ice readvance can be upheld with further evidence, then there may have been a local climatic change that affected both ice ablation and plant growth.

Many difficulties must be overcome before this correlation can be accepted. One difficulty is the fact that the reversion in the pollen record at Lake Mary may be due to overlapping core segments (Webb, 1974, p. 23). Also, Brubaker (1975) published the pollen records of several lakes situated about 50 km west of Marquette, probably very close to the limit of the Marquette readvance, but these show no evidence for an early Holocene vegetational fluctuation. However, although some of Brubaker's sites date beyond 10,000 yr B.P., there is a possibility that they are located within the border of the ice advance. The lakes studied by Saarnisto (1974) near Sault Ste. Marie would have been relatively close to the ice front at that time, but their pollen stratigraphies also give no indication of a climatic fluctuation. Clearly, more work must be done on mapping the limits of the ice readvance, as well as examination of pollen stratigraphies from nearby sites.

An additional point of interest concerning any ice advance from the central Lake Superior basin at the Pleistocene–Holocene boundary is that it apparently would have preceded the post-Duluth series of glacial lake stages in the western Lake Superior basin. At several of the sites reported by Black (1976, p. 110), Lake Duluth shorelines are well developed above the wood-bearing tills. Likewise, the ice that stood at the Marquette moraine when the Gribben forest was buried would have covered any eastward drainage outlets of the post-Duluth lakes. Black dispenses with this difficulty by suggesting a local ice cap on the south side of Lake Superior rather than ice occupying central Lake Superior itself at that time. This explanation appears rather dubious.

Deglaciation of the Lake Superior Basin

The geographic distribution of post-Main Algonquin shorelines observed in this study suggests that the retreat of ice from the Munising moraine, starting ca. 10,600 yr B.P., was not uniform. Shorelines pertaining to water plane b and lower ones are abundant on the ice-contact slopes of the segment of this moraine east of the 85°30′W meridian. To the west, the highest shorelines on the northern slopes of this moraine appear to be at the level of water plane c or lower. The highest glacial outwash channel near Grand Marais is probably graded to the level of water plane c. It appears that the southeastern Lake Superior basin was becoming clear of ice while ice remained in contact with upper Michigan in the area of Grand Marais and to the west. In agreement with this is the evidence that an ice lobe still covered the central Lake Superior basin, parts of central and western upper Michigan, and northern Wisconsin ca. 9900 yr B.P. The glacial lakes extending into the eastern Lake Superior basin were the first post-Main Algonquin lakes, which also were occupying the Lake Huron and Lake Michigan basins.

Meanwhile, ice retreat in the western Lake Superior basin allowed the expansion of Lake Duluth, which drained into the Mississippi River system. In the course of the final retreat of the ice from central upper Michigan, starting before 9800 yr B.P., a series of lower outlets was uncovered to the east. Through these, the post-Duluth glacial lakes first drained into a post-Main Algonquin lake occupying the Lake Michigan basin, and later into one in the Lake Superior basin (C. W. Drexler, personal communication, 1980).

By about 9500 yr B.P. the Lake Superior basin was free of ice and Lake Minong had been established. Whether the level of Lake Minong was controlled by a post-Algonquin lake in the Huron basin or by a threshold near Sault Ste. Marie is still in question (Saarnisto, 1975, pp. 314–316). The Nodoway Point area mentioned by Saarnisto (1975, Fig. 16) should be a key locality with respect to this question, for it has many well-developed shorelines pertaining to the Algonquin–Minong transition, at the point where the Superior and Huron basins interconnect.

SUMMARY

Evidence presented here on previously unreported glacial lake shorelines in eastern upper Michigan enables one to revise current lake stage and ice-front position correlations in this region (e.g., Hough, 1958; Saarnisto, 1974, 1975). Data from 35 sites in upper Michigan show the existence of several warped water planes, the uppermost of which is continuous with the Main Lake Algonquin shorelines in eastern Wisconsin and near Sault Ste. Marie, Ontario. The direction of maximum tilt of this water plane is N15°E, which agrees with that of the water plane of Lake Algonquin in the Lake Michigan basin as drawn by Goldthwait (1910). Other important reasons for correlating the highest shorelines in eastern upper Michigan with the Main Lake Algonquin stage are as follows:

(1) Shorelines pertaining to the highest water plane are well developed, with strongly cut terraces and scarps, large beach ridges, and spits. At sites where shore features of several different lake stages are visible, the one associated with the highest water plane is usually the strongest. This suggests that the first lake stage was long-lived, as Main Lake Algonquin is known to have been elsewhere.

(2) Radiocarbon dates (Saarnisto, 1974) from the vicinity of Sault Ste. Marie, Ontario, indicate that the highest water plane locally, which is continuous with the highest water plane in adjacent upper Michigan, belonged to a lake stage that ended by 10,650 yr B.P. This date agrees well with the date of ca. 10,600 yr B.P. for the end of the Main Lake Algonquin stage (Karrow *et al.*, 1975).

At the time of the maximum extent of Main Lake Algonquin most of eastern upper Michigan was submerged, except for numerous small islands which are the highest portions of the Niagara escarpment and the Newberry moraine, both of which traverse the region from east to west. The ice front was then positioned along the Munising moraine, the northern of the two principal morainic systems of the region. The south flanks of this moraine are fringed with large outwash aprons graded to the level of Main Lake Algonquin, indicating that the ice front reached this position by 10,600 yr B.P.

This interpretation lends some support to the hypothesis of Saarnisto (1974) of a cold period marked by very slow deglaciation in the upper Great Lakes region between 11,000 and 10,100 yr B.P., which he calls the Algonquin Stadial. Ice retreat remained slow for a small period beyond this time, particularly in the central Lake Superior basin, which was occupied by ice while proglacial lakes were expanding in the eastern and western basins of Lake Superior. There is evidence from upper Michigan and northern Wisconsin for a minor ice advance from the central Lake Superior basin at about or shortly after 10,000 yr B.P., just out of phase with the Algonquin Stadial. Evidence for this comes from radiocarbon-dated wood specimens found embedded in till or outwash, including a large buried forest near Marquette, Michigan. The mean of five radiocarbon dates from this site is 9925 yr B.P. J. D. Hughes (personal communication, 1980) proposes the name Marquette Stadial for the period of ice advance, and the name Gribben Interstadial for the preceding period during which the buried forest had been growing. Such an ice readvance would have precluded the development of the post-Duluth series of glacial lakes in the western Lake Superior basin until early Holocene time. A possible climatic fluctuation represented by changes in the pollen diagrams from several sites in upper Michigan and northern Wisconsin (Webb, 1974) may be associated with the Marquette ice readvance.

It is apparent that our concepts on the geography and chronology of ice retreat in the Lake Superior region are in a state of flux. As new pieces to the puzzle fall into place, it will be necessary to reexamine some of the stratigraphic nomenclature that has been used to describe these events, in particular the terms Algonquin Stadial, Gribben Interstadial, and Marquette Stadial.

APPENDIX

A. Ancient Shorelines Observed in Upper Michigan

Site no. and name	Topographic quadrangle & location	Description of feature; elevation
1. SE of Cooks	Cooks (15'); sects. 5, 6, 7, and 18, T 40 N, R 17 W.	Large spit ca. 7 km long; crest elev. 227 m (745 ft).
2. Cooks Moraine, E side	Cooks (15'); sects. 3 and 10, T 41 N, R 17 W.	Wave-cut scarp and terrace; ca. 229 m (750 ft.). (cf. Bergquist, 1936, p. 101)
3. Cooks Moraine, N side	Steuben (15'); NW 1/4, NW 1/4, sect. 28, T 42 N, R 17 W.	Beach ridge at ca. 232 m (760 ft) (cf. Bergquist, 1936, p. 101)
4. Eckerman Corner	Eckerman (7.5'); NE 1/4, sect. 35, T 46 N, R 6 W.	Possible shore scarp and terrace; 274 m (900 ft).
5. N of Epoufette	Epoufette (7.5'); SE 1/4, sect. 22, T 43 N, R 7 W.	Possible shore scarp at 256 m (840 ft), strong scarp at 247 m (810 ft).
6. W of McMillan	Hardwood Island (7.5'); NE 1/4, sect. 2, T 45 N, R 12 W.	Spit at 259–262 m (850–860 ft), possible beach ridges at 262 m (860 ft); (cf. Bergquist, 1936, pp. 95–96).
7. NW of Hessel	Hessel (7.5'); sect. 32, T 43 N, R 1 W.	Scarp and terrace at 265 m (870 ft); (cf. Taylor, 1895).
8. Italian Hill	Hessel (7.5'); sect. 8, T 42 N, R 1 W.	Scarp and terrace at 241 m (790 ft); identified as lowest beach of Algonquin upper group (Leverett and Taylor, 1915, plate XXIII).
9. NE of Rockview	Hessel (7.5'); NW 1/4, sect. 35, T 43 N, R 1 W.	Possible spit at 259 m (850 ft).
10. McNearney Lake	McNearney Lake (7.5'); NE 1/4, sect. 6, T 46 N, R 5 W.	Possible beach scarps at 283 m (930 ft) and 277 m (910 ft).
11. W of Mervin Lake	Newberry (7.5'); SE 1/4, sect. 21, and NW 1/4, SW 1/4, sect. 22, T 45 N, R 10 W.	Scarp and terrace at 262 m (860 ft).
12. Newberry	Newberry (7.5'); SW 1/4, NW 1/4, and NW 1/4, NE 1/4, sect. 10, T 45 N, R 10 W; NW 1/4, NW 1/4, sect. 10, T 45 N, R 10 W.	Small knobs surrounded by terraces at 262–265 m (860–870 ft); (cf. Bergquist, 1936, pp. 95–96); scarp and terrace at 241 m (790 ft).
13. 54 Pond	Ozark (7.5'); SW 1/4, sect. 22, T 44 N, R 5 W.	Spit; crest at 265 m (870 ft).
14. Scott Quarry	Ozark NE (7.5'); sect. 29, T 44 N, R 4 W.	Scarp and terrace at 265 m (870 ft).
15. Maple Hill, N side	Ozark NE (7.5'); SE 1/4, sect. 34, T 44 N, R 4 W.	Beach ridge and cliff at 265 m (870 ft); series of lower beach ridges.

APPENDIX—*Continued*

Site no. and name	Topographic quadrangle & location	Description of feature; elevation
16. Maple Hill, E side	Ozark NE (7.5'); NW 1/4, NW 1/4, and NE 1/4, SW 1/4, sect. 11, T 43 N, R 4 W.	Beach ridges at 265 m (870 ft); lower ridge at ca. 259 m (850 ft).
17. East Lake	Ozark SE (7.5'); NE 1/4, NW 1/4, sect. 21, T 43 N, R 4 W.	Beach ridge at 261 m (855 ft).
18. Eckerman lookout tower	Piatt Lake (7.5'); SE 1/4, sect. 1, T 47 N, R 7 W.	Scarps and terraces at 262 m (860 ft) and 280 m (920 ft).
19. N of Rexton	Rexton (7.5'); NE 1/4, sect. 25, T 44 N, R 8 W.	Possible spit at 259 m (850 ft).
20. NE of Rexton	Rexton (7.5'); sect. 29, T 44 N, R 7 W.	Possible scarp at 259 m (850 ft).
21. S of McLeods Corner	Soo Junction (7.5'); NE 1/4, SE 1/4, sect. 36, T 45 N, R 9 W.	Scarp and terrace at 262 m (860 ft)
22. McLeod Hill	Soo Junction (7.5'); NE 1/4, sect. 35, T 45 N, R 8 W.	Scarp and terrace at 265 m (870 ft), spit at 265 m (870 ft).
23. Dick Rd.	Strongs (7.5'); sects. 11, 14, 15, 22, 27, and 34, T 45 N, R 5 W	Large spit; crest at 271–274 m (890–900 ft).
24. W of Raco	Sullivan Creek (7.5'); sects. 23 and 24, T 46 N, R 4 W.	Shore cliff and terrace; 268 m (880 ft).
25. Tahquamenon Delta	Tahquamenon Lakes (7.5'); sects. 7, 8, 9, 10, 11, 12, 14, 15, 16, and 17, T 46 N, R 12 W.	Edge of deltaic outwash plain; 262–268 m (860–880 ft). Fluvial and shore terraces at 244 m (800 ft) and 229 m (750 ft).
26. SW of Timberlost	Timberlost (7.5'); NE 1/4, sect. 20, and NW 1/4, sect. 21, T 48 N, R 7 W; SE 1/4, NE 1/4, sect. 20, T 48 N, R 7 W.	Scarp and terrace at 287 m (940 ft); possible beach ridge at 293 m (960 ft).
27. Grass Lake	Cooks (15'); SW 1/4, NW 1/4, sect. 3, T 40 N, R 17 W.	Beach ridge at 213 m (700 ft) on N side of Grass Lake.
28. Boot Lake outwash plain	Shingleton (15'); sects. 21, 22, 23, 26, 27, 28, 33, 34, and 35, T 45 N, R 17 W; sect. 7, T 45 N, R 17 W.	Top surface of outwash plain at ca. 250 m (820 ft). (cf. Bergquist, 1936, p. 85); terrace at 247–250 m (810–820 ft).
29. Wolverine Lake	Buckeye Lake (7.5'); sect. 34, T 47 N, R 11 W.	Outwash plain surface at ca. 268 m (880 ft).
30. E Soldier Lake	Sullivan Creek (7.5'); sects. 30 and 31, T 46 N, R 4 W.	Outwash plain surface at 274–277 m (900–910 ft).
31. Douglas Lake (Cheboygan Co.)	Mullett Lake (15'); sects. 28 and 33, T 37 N, R 3 W.	Scarp and terrace at 227 m (745 ft).
32. Sunken Lake	Sunken Lake (7.5'); sects. 22, 27, and 34, T 47 N, R 14 W.	Outwash plain surface at 265–268 m (870–880 ft).
33. Mission Hill	Dollar Settlement (7.5'); SW 1/4, sect. 15, T 47 N, R 3 W.	Scarp and terrace at 268 m (880 ft).
34. Dollar Settlement	Dollar Settlement (7.5'); SE 1/4, sect. 25, T 47 N, R 4 W.	Scarp and terrace at 259 m (850 ft).
35. S of Dollar Settlement	Dollar Settlement (7.5'); SW 1/4, sect. 31, T 47 N, R 3 W.	Scarp and terrace at 274 m (900 ft).

APPENDIX—*Continued*

B. Previously Described Glacial Shorelines in Michigan, Ontario, and Wisconsin

Site no. and name	Location	Description and reference
36. Burnt Bluff	Delta Co., Mich.	Algonquin beach at 219–221 m (720–725 ft); upper group: 218, 216, 210–212 m (715, 710, and 690–695 ft); Wyebridge at 197–198 m (645–650 ft). (Prahl & Farrand, 1968)
37. Beaver Island	Charlevoix Co., Mich.	Main Algonquin at 223 m (730 ft); correlative of Battlefield level at 207 m (680 ft). (Dietrich, 1978)
38. Mackinac Island	Mackinac Co., Mich.	Algonquin beach at 247 m (809 ft); lowest beach of upper group at 232 m (760 ft); Battlefield beach at 218–219 m (715–719 ft). (Leverett and Taylor, 1915, plate XXIII)
39. Cross Village	Emmet Co., Mich.	Algonquin beach at 227 m (746 ft), Battlefield beach at 210 m (689 ft). (Leverett and Taylor, 1915)
40. Odena	Algoma Dist., Ont.	Glaciofluvial delta at 312 m (1025 ft). (Saarnisto, 1975, Table 2)
41. Korah	Algoma Dist., Ont.	Glaciofluvial delta at 309 m (1015 ft). (Saarnisto, 1975, Table 2)
42. Rock Island	Door Co., Wisc.	Algonquin beach at 207 m (680 ft). (Goldthwait, 1907, plate II)
43. Death's Door Bluff	Door Co., Wisc.	Algonquin beach at 201 m (659 ft). (Goldthwait, 1907, plate II)
44. Ephraim	Door Co., Wisc.	Algonquin beach at 196 m (643 ft). (*ibid.*)
45. Horseshoe Bay	Door Co., Wisc.	Algonquin beach at 192 m (631 ft). (*ibid.*)
46. Sawyer	Door Co., Wisc.	Algonquin beach at 187 m (619 ft). (*ibid.*)
47. Cormier	Brown Co., Wisc.	Algonquin beach at 186 m (609 ft). (*ibid.*)
48. Two Rivers	Manitowoc Co., Wisc.	Algonquin beach at 185 m (606 ft). (*ibid.*)

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