EVIDENCE OF ANCIENT LEVELS OF LAKE SUPERIOR IN THE HURON MOUNTAINS AREA

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INTRODUCTION

Nature of the study. The Huron Mountains area, Marquette and Baraga counties, Michigan, was studied in the period 1-10 September 1959 in order to identify geologic features related to ancient water levels of the Lake Superior basin. During this brief visit the following areas were investigated: (1) the present shoreline, (2) the ancient beach ridges and wave-cut bluffs just above the present shore, (3) the Huron Mountains and their contained lake basins, and (4) the extensive Yellow Dog sand plains south of the mountains. Whereas this study should be considered as a separate geologic field investigation, the data collected and reported herein have been included as an integral part of the author's doctoral dissertation which is on file at the University of Michigan (Farrand, 1960).*

Background of the subject. A few remarks are pertinent at this point concerning the general outline of the geologic history of the past 11,000 years in the Lake Superior region. At about 11,000 to 10,800 years ago the latest advance of the great continental ice sheet covered the entire Lake Superior basin and extended some distance southwest of Duluth, Minnesota, and as far south as Muskegon, Michigan, and Milwaukee, Wisconsin, in the Lake Michigan basin. As this ice sheet

*References cited are listed at the end of the report.

retreated within the rim of the Superior basin its meltwater was ponded between the ice front and the highlands in northern Wisconsin, Michigan, and Minnesota. The lakes thus created discharged first southwestward into the Mississippi, but, later, lower outlets to the Lake Michigan basin were opened. Next, the eastern lowland of Michigan's Upper Peninsula was freed by the glacier, and ancient lakes in the Superior, Huron and Michigan basins were joined at a common level via broad straits across the Upper Peninsula. Ultimately the glacier uncovered an extremely low outlet east of Georgian Bay (Lake Huron), and the Upper Great Lakes were drained to levels 240 to 400 feet below their present levels. Post-glacial rebound (see following paragraph) lifted this low outlet above the level of the St. Clair River at Port Huron, and the drainage of the Upper Great Lakes was returned to that route, which has been used ever since, and the important Nipissing Great Lakes were initiated. Since that time the water levels in the upper lakes have dropped gradually to their present levels.

The great continental glacier which covered north central and northeastern United States and almost all of Canada to a thickness of two or three miles greatly depressed the crust of the earth beneath it. Consequently, as the glacier melted away the crust was gradually restored to its original elevation. However, the lakes which formed in the Great Lakes area at the edge of the ice sheet came into existence before the crust had rebounded completely. Their shorelines, therefore, subsequent to their formation, have been uplifted--more on the northeast where the ice sheet was thicker than on the

southwest side of the basins--and are no longer horizontal. For example, some of the older shorelines are nearly 600 feet higher in the northeast corner of Lake Superior than they are in the southwest near Duluth. The younger shorelines are not tilted nearly so much: the Nipissing beach rises only about 120 feet between Duluth on the southwest and Marathon, Ontario, on the northeast. The records of lake level guages indicate that this uplift is continuing at present but at a greatly reduced rate; in other words, the crust has been restored nearly to its pre-glacial condition.

The best detailed and recent review of the history of the Great Lakes is Hough's (1958) Geology of the Great Lakes. The chapters on Lake Superior, however, have been completely rewritten by the present author (Farrand, 1960) on the basis of recent field work. Andrist (1960) has recently written an excellent, brief account of the nature of the Pleistocene ice ages, their effects on North America and their causes.

In the report which follows features in the Huron Mountains area relating to the ancient lakes will be described first. This will be followed by a detailed summary of the history of Lake Superior as interpreted by the author.

Acknowledgments. This study was made possible by the Huron Mountain Wildlife Foundation in terms of room and board at the Huron Mountain Club and the use of Club facilities. Mr. and Mrs. Laird Bell were very gracious hosts to my wife and me, and Mr. William P. Harris was very helpful in supplying information, aerial photographs and maps of the Club

area. Our visit was made very pleasant overall by all the members of the Huron Mountain Club.

FIELD INVESTIGATIONS

Nipissing and post-Nipissing lake stages

Background. The Nipissing Great Lakes, comprising the immediate ancestors of Lakes Superior, Huron and Michigan, came into being about 4000 years ago and were relatively long-lived compared to their predecessors. Furthermore, the Nipissing stage followed an extremely low stage (Houghton stage) when the water level dropped to 360 feet above sea level in the Superior basin and to similar low levels in the Huron and Michigan basins. The combination of the long life of Nipissing Lake Superior and the fact that waters rising from lower to higher levels have a tendency to build stronger shoreline features accounts for the great strength of Nipissing beach ridges and wave-cut bluffs which are found throughout the Upper Great Lakes. The Nipissing ridges and bluffs are always found quite close to the present shore: the original altitude of the Nipissing Great Lakes was 605 feet above sea level (compared to 602 feet for present-day Lake Superior), and in most parts of the Upper Great Lakes the Nipissing beach has been elevated no more than a few tens of feet by post-glacial rebound. Therefore, the Nipissing beach is usually quite accessible for study.

The Nipissing beach. On the lakeward flank of the Huron Mountains prominent sand ridges and wave-cut bluffs of Nipissing Lake Superior are very evident in every cove and bay

(see Plate I). From the west side of Pine River Point the Nipissing shoreline can be traced with hardly a break to Huron River Point and on beyond Flatrock. About one mile east of the Club cabins the trail to Pine River Point ascends a very steep and high sand bluff which was cut by the waves of Nipissing Lake Superior. This bluff is about 40 feet high, its base is 621 feet above sea level, and a low ridge of beach pebbles lies at its base.

Walking westward along the base of this bluff one finds that the bluff decreases in height and then is replaced by a very bold ridge of wave-washed sand. This ridge is up to 100 feet wide and its crest reaches 635-640 feet above sea level; it can be followed from the south center of Section 22, T. 52 N., R. 28 W., along the south side of Pine River and along the northwest side of Pine Lake. In some places the ridge is rather diffuse and has several crests. On the south side of the ridge there are two basins which were lagoons in Nipissing time: Cranberry Bog and the marshy sand flats surrounding it, and Pine Lake itself which is now sealed from Lake Superior by the Nipissing beach ridge.

Continuing westward, the Nipissing shoreline is next represented by the very strong wave-cut bluff below the Skeet Field (north center, Section 20, T. 52 N., R. 28 W.). The base of the bluff here is 626 feet above sea level and the bluff is 45-50 feet high. Farther west, at Flatrock there is a lower bluff, only 18-20 feet high, whose base is 625 feet. Both of these bluffs have accumulations of beach materials (shingle, gravel) at their bases.

In the eastern part of Club property the Nipissing shoreline is well developed at Conway Bay and across the Salmon Trout River valley. Like Pine Lake, Conway Lake is held in by a strong Nipissing sand ridge whose crest is about 630 feet above sea level. The road leading to the Club crosses the Salmon Trout valley along the crest of a Nipissing beach ridge with crest also about 630 feet. The valley of Conway Creek which connects the Conway Lake and Salmon Trout valleys was a shallow arm of Nipissing Lake Superior which turned the headland which now constitutes Conway Point into a near-shore island in Nipissing time.

At the time of the Nipissing Great Lakes, therefore, the coastline flanking the Huron Mountains was considerably more indented and irregular than the present shoreline, as shown on the accompanying map, Plate I. The construction of Nipissing and post-Nipissing beaches has smoothed the coastal contour considerably.

Post-Nipissing features. As anyone who has walked through the pine woods east of the Pine River knows, there are numerous old beach ridges between the present shore and the Nipissing beach as described above. These beaches were formed as lake level gradually and regularly fell from the Nipissing level. Superimposed on this gradually falling level were minor fluctuations of much shorter period, such as are observed to occur in the Great Lakes today. For example, the U. S. Lake Survey records show four maximum levels separated by times of lower water within the last century.

Just east of the big bend of the Pine River twenty low beach ridges were encountered; their crests range from 612 feet to 636 feet above sea level, whereas the larger Nipissing beach just beyond reaches 641 feet. Although the post-Nipissing beaches were not precisely measured elsewhere, they are conspicuous immediately south and southwest of the Club buildings and also across the lower valley of the Salmon Trout River between the road and the present shore. Aerial photographs show the ridges in the latter area very well. Numerous ridges of the same nature are situated on the lakeward flank of the tremendous Nipissing ridges which separate Lake Independence from Lake Superior at Big Bay, Michigan.

At many places along the north shore of Lake Superior one to three distinct beaches can be seen between the Nipissing and present shorelines. These beaches have been named the Algoma, Sault, and Sub-Sault beaches, in descending order. At other places along the north shore a continuous succession of equally developed beach ridges occupy this same interval. In the Huron Mountains area the Sault and Sub-Sault beaches are below present lake level, but the Algoma beach is expected at about 610-615 feet. However, it does not seem possible to separate the Algoma beach from the post-Nipissing succession described in the preceding paragraph.

Pre-Nipissing Shoreline Features

Although several benches and sand and gravel deposits were noted on the mountain slopes above Pine, Rush and Howe lakes, no unequivocal evidence of an old shoreline above the

Nipissing beach was found. Several conspicuously level areas at about 800 feet above sea level were suggestive of shorelines, but more likely they are controlled by the underlying bedrock. Several ancient shorelines occupy this same interval in northern Wisconsin, but those lakes were quite short-lived and required optimum conditions for the construction of recognizable shore features. The rocky and rugged topography of the Huron Mountains precluded their preservation here.

Huron Mountains Outlet Channel

The earliest and highest of the ancient lakes which occupied the Superior basin were confined to the western part of the basin and drained southwestward into the Mississippi River system. The edge of the continental ice sheet covered all possible eastern outlets at that time. Slightly later, however, the glacier retreated from the bedrock upland in the Huron Mountains-Marquette area, and outlets lower than those to the southwest were opened to Lake Michigan. Leverett (1929, p. 63) suggested such an ice retreat from the slopes of the Huron Mountains but did not publish any detailed description of this retreat or the outlets that it uncovered. However, his knowledge of the area was greatly limited by heavy forest cover, the lack of detailed topographic maps, and the non-existence of aerial photography.

Inspection of the new topographic maps for this area revealed a very steep and high north-facing scarp just south of the Huron Mountains; this area, therefore, was studied with respect to the problem of eastern outlets. This prominent

scarp, which is about 400 feet high, forms the north edge of the extensive sand flat known as the Yellow Dog Plains. The surface of the Yellow Dog Plains just above the scarp is about 1500 feet above sea level and slopes gradually to the south to an altitude of about 1450 feet. Furthermore, it contains numerous shallow, more or less conical depressions known as kettle holes, which resulted from the melting of buried blocks of ice. This unusually flat area in the midst of a rocky upland and the presence of kettle holes indicates that the Yellow Dog Plains is an outwash deposit, that is, it is composed of sand and some gravel which was washed out from the edge of the retreating glacier by meltwater streams. The high scarp, therefore, is an ice-contact slope, which means that the edge of the continental ice sheet was standing against this scarp while meltwater from the ice sheet carried vast quantities of sand and gravel into the area of the Yellow Dog Plains. Small ice bergs were also carried into this area by the meltwater; they were buried and then melted forming kettle holes long after the Yellow Dog Plains were completely formed. The Yellow Dog Plains are 200 feet higher than any known shorelines in the Superior basin, allowing for post-glacial uplift, and therefore are in no way connected to ancient lake levels.

As the glacier retreated from its position on the north side of the Yellow Dog Plains it opened a large channel, bounded on the south by the high scarp just described and on the north by the front of the glacier itself. The bottom of this channel is now just above 1100 feet but was about 170 feet

lower when it was originally opened. The lakes in western Superior basin, which were previously held to high levels (Lake Duluth) by the presence of the ice sheet against the edge of the Yellow Dog Plains, could now drain eastward through this large channel and discharge into the Lake Michigan basin. The opening of the Huron Mountains outlet thus initiated a transitional series of lakes referred to as the Post-Duluth series. The configuration of this channel is shown in Profile A-A' on Plate I.

The Post-Duluth lakes fell from levels just above 1000 feet to below present lake level in the Duluth area; the equivalent elevations of these lakes in the Huron Mountains area, where these shorelines have been uplifted, are 1175 feet down to about 700 feet above sea level. Since the floor of the large channel between the Huron Mountains and the Yellow Dog Plains is around 1100 feet, it is obvious that only the higher Post-Duluth lakes could have discharged through it. As the glacier continued its retreat northward across the Huron Mountains lower and lower passes must have been uncovered, and many possible passes exist in the area (such as the Lake Ann valley), but it was not possible to specify which routes were actually used. The short duration of the Post-Duluth lakes, probably less than 100 years each, did not allow time for significant modification of the rocky topography of the Huron Mountains by lake waters. It is conceivable that these lower outlet channels will never be conclusively located.

DISCUSSION

Review of the History of Lake Superior

A discussion of the history of Lake Superior can begin with the maximum extent of the Valders substage of the Wisconsin ice sheet. The Wisconsin stage was the last of the four expansions of a continental ice sheet (such as those now in Greenland and Antarctica) which occurred within the past one million years and covered all of Canada and the northern United States to the Ohio and Missouri rivers. These four glaciations were separated by interglacial intervals in which the climate was similar to today or even warmer. The Wisconsin stage began around 50,000 to 70,000 years ago, perhaps, and was characterized by several fluctuations or pulsations. The last important pulsation was the Valders substage which reached its maximum extent southwest of Duluth and near Milwaukee about 10,800 years ago. As the lobe of the Valders substage which occupied the western half of the Superior basin retreated within the confines of the basin, its meltwater was trapped between the highland rim in northern Wisconsin and Minnesota and the front of the ice sheet. These ponded waters overflowed at the lowest available points, which first were a pass at Moose Lake, Minnesota, and a pass which connects the headwaters of the Brule and St. Croix rivers in northern Wisconsin. The earliest lakes were small, separate water bodies (Hough, 1958, p. 188-189; Leverett, 1929, p. 55-57), and probably came into being about 10,500 years ago.

As the ice sheet continued to retreat these small lakes merged into one large lake, known as Glacial Lake Duluth. This stage

is shown in Figure 1. The highest shoreline of Lake Duluth is at 1085 feet above sea level in Duluth, and other Lake Duluth beaches occur down to about 1035 feet. As the level of Lake Duluth was falling the Moose Lake outlet was abandoned and all the drainage passed through the Brule-St. Croix outlet. The ice continued to retreat throughout this time, but it still lay over the Huron Mountains.

When the glacier finally retreated from the north slope of the Yellow Dog Plains a passage to the east was opened and the Post-Duluth series of lakes was initiated. There are at least seven distinct shorelines attributed to this series, although they are rarely strong features. An intermediate member, the Washburn stage, is depicted in Figure 2. Note that part of Isle Royale and Keweenaw Peninsula was ice free at this stage, but that the edge of the glacier persisted on the eastern part of the Upper Peninsula of Michigan.

The next important stage of ancestral Lake Superior is shown in Figure 3. By this time the glacier had retreated across the lake and occupied a position along the north shore, and Glacial Lake Minong, which occupied the entire perimeter of the basin for the first time, was created. This occurred about 9000 years ago. Lake Minong was connected by the St. Marys strait and the Au Train-Whitefish strait to a lake at the same level (about 450 feet above sea level) in the Michigan-Huron basin ("Lake Sheguiandah" of Hough, 1958, p. 234-235).

About 500 years after Lake Minong was initiated the glacier retreated from the Lake Nipissing-Mattawa River valley

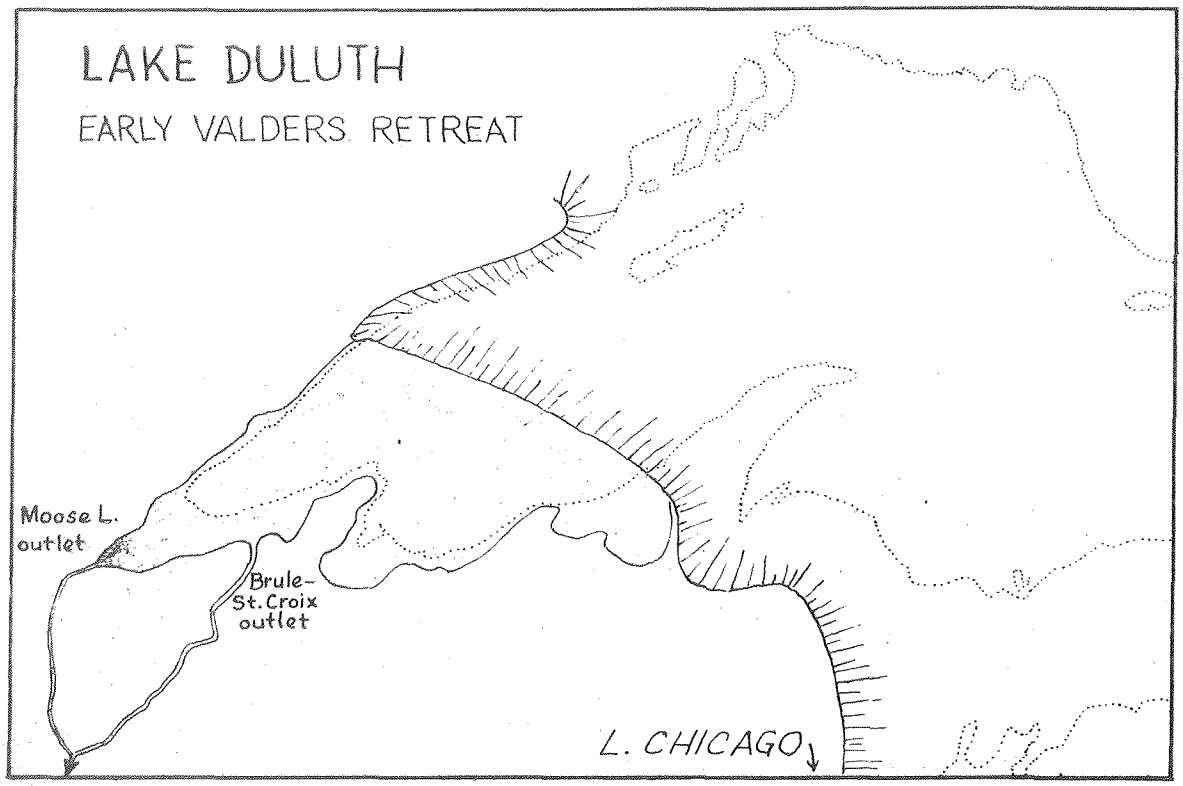


Figure 1. Lake stage map: Lake Duluth, showing ice barrier and indicating contemporary lake in Michigan basin.

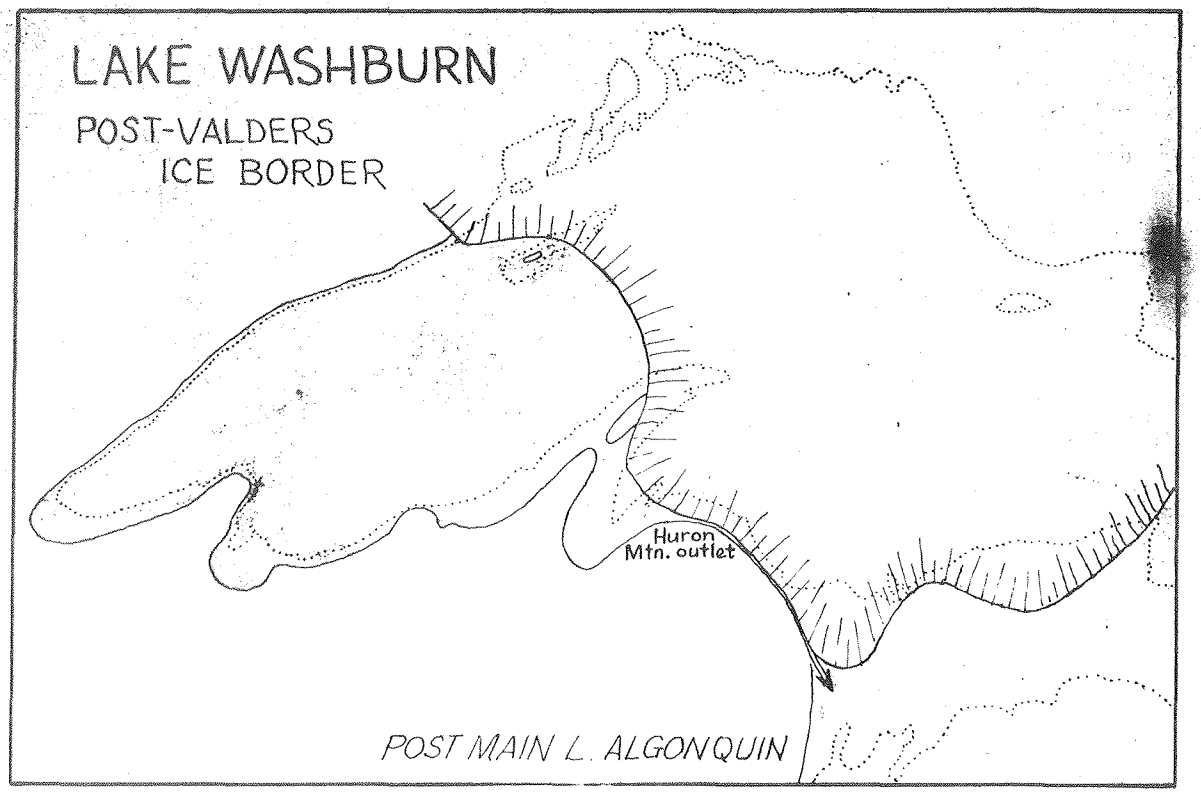


Figure 2. Lake stage map: Lake Washburn (Post-Duluth series), showing ice barrier and contemporary lake in Michigan-Huron basin.

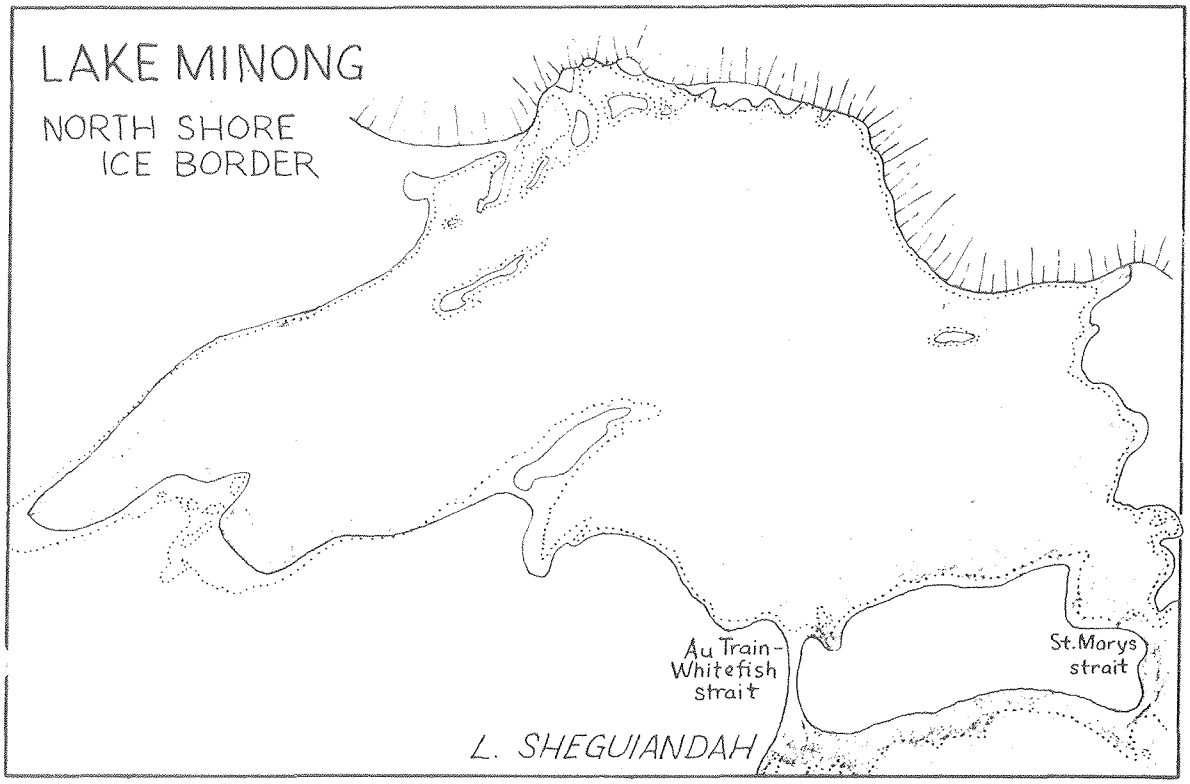


Figure 3. Lake stage map: Lake Minong, showing ice border and contemporary lake in Michigan-Huron basin.

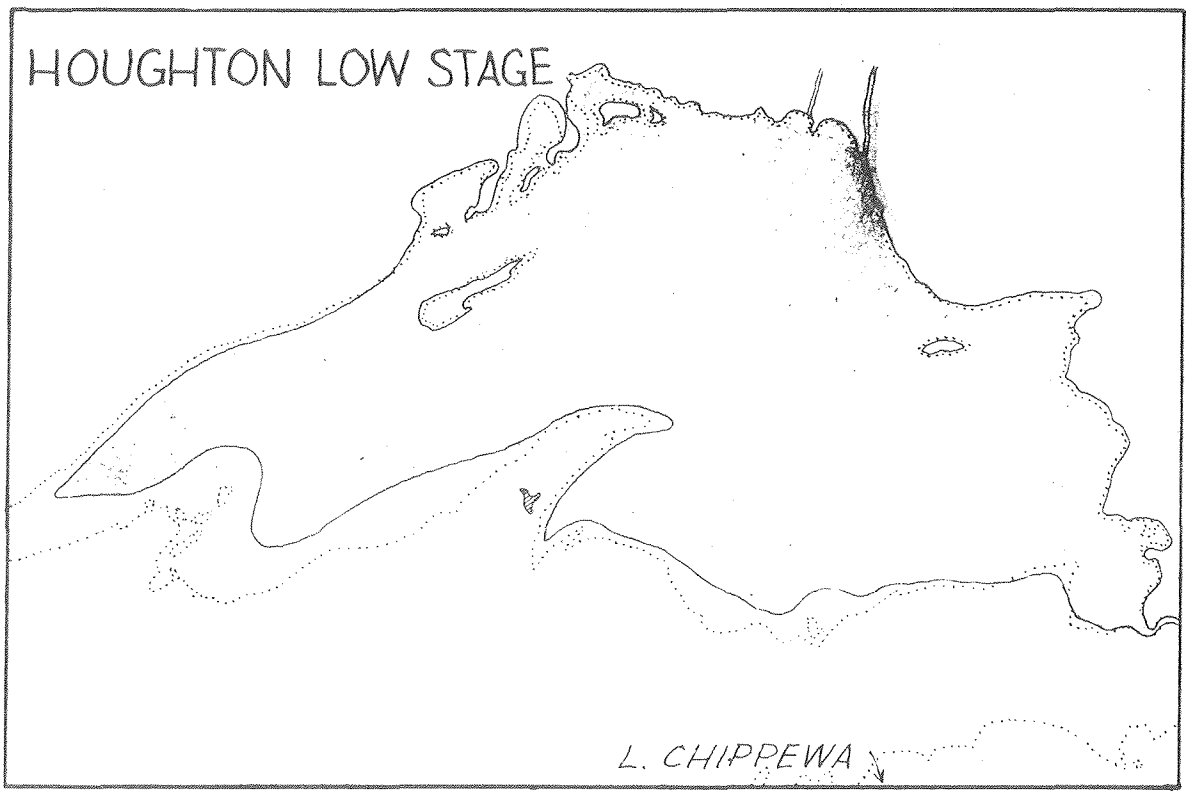


Figure 4. Lake stage map: Houghton low stage, indicating contemporary lake in Michigan basin; L. Stanley was contemporary in Huron basin.

northeast of Georgian Bay. Since that area then stood only about 180 feet above sea level the Upper Great Lakes were drained to extremely low levels: Lake Stanley (180 feet) in the Huron basin, Lake Chippewa (230 feet) in the Michigan basin, and Lake Houghton (360 feet) in the Superior basin (see Figure 4). Large areas now submerged along the south shore of Lake Superior were exposed to the air during the Houghton low stage. The Houghton shoreline is now submerged by about 75 feet of water off the Huron Mountain coast, where it has been uplifted about 170 feet above its original depth of 240 feet.

Upon deglaciation the Nipissing-Mattawa valley began to rise slowly in response to removal of the ice load. At approximately 4000 years ago this outlet valley had risen to the same level as the St. Clair River, which lies south of the area affected by uplift, and the Upper Great Lakes again discharged to Lake Erie as they had done previously and have done since that time. During the transfer of discharge from the Mattawa valley to the St. Clair River the Nipissing Great Lakes were formed at 605 feet above sea level in the three upper lakes, and prominent beaches and wave-cut bluffs were produced. These features are quite prominent along the Huron Mountains coast at 625-640 feet. The outline of Nipissing Lake Superior was very similar to that of the present shoreline, except in local details as shown in Plate I.

Following the complete transfer of discharge to the St. Clair river, the Port Huron sill was slowly eroded by the lake waters. Lake levels slowly dropped from the Nipissing level.

About 3200 years ago there was an apparently static stage, named Lake Algoma, at 596 feet above sea level. The Algoma shoreline should lie about 10 to 15 feet above the present water level in the Huron Mountains area, but no distinctive beach was found there.

About 2000 years ago post-glacial rebound raised the Sault in the St. Marys River above the level of the joint lake which then occupied the Huron-Superior-Michigan basin. Thus a separate Lake Superior was created. However, uplift had not yet ceased and the Sault continued to rise and the Superior basin continued to tilt. Since the outlet of the Superior basin is located along one side of the basin with respect to the direction (NE-SW) of uplift, the northeast shore of the lake was successively elevated as the southwest shore was drowned.

Two distinct shorelines formed since the Sault first emerged. The older of these is the Sault beach which now lies about 45 feet above lake level on the north shore but is 10 to 15 feet below the lake off the Huron Mountains coast. The younger Sub-Sault beach lies about 25 feet above the lake on the north shore and perhaps five feet below lake level in the vicinity of the Huron Mountain Club.

Summary

The history of Lake Superior is summarized in Table I (below). Investigations reported in an earlier portion of this paper of the prominent outlet channel between the Huron Mountains and the Yellow Dog Plains have made it possible to

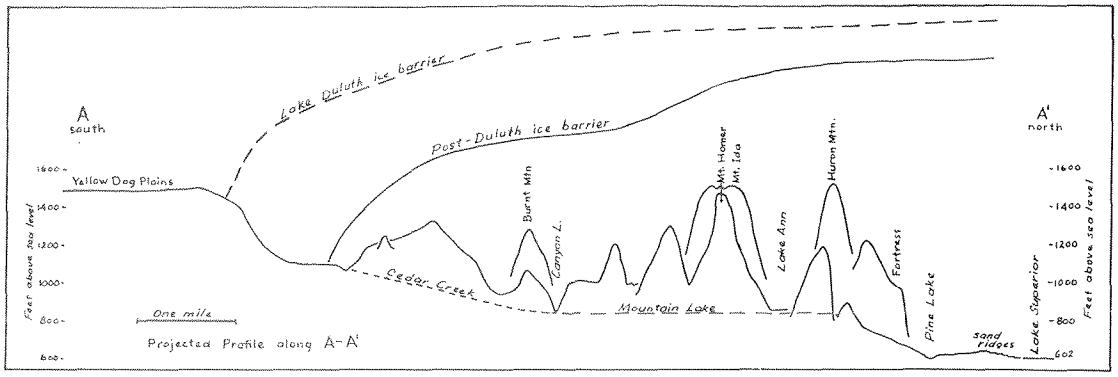
work out the history of the Post-Duluth series of lakes in considerably more detail than was previously known. Perhaps further investigations will identify some later channels and shorelines of the Post-Duluth lakes, but considering the ruggedness of the topography in the Huron Mountains and the short lives of those lakes it will be a difficult task.

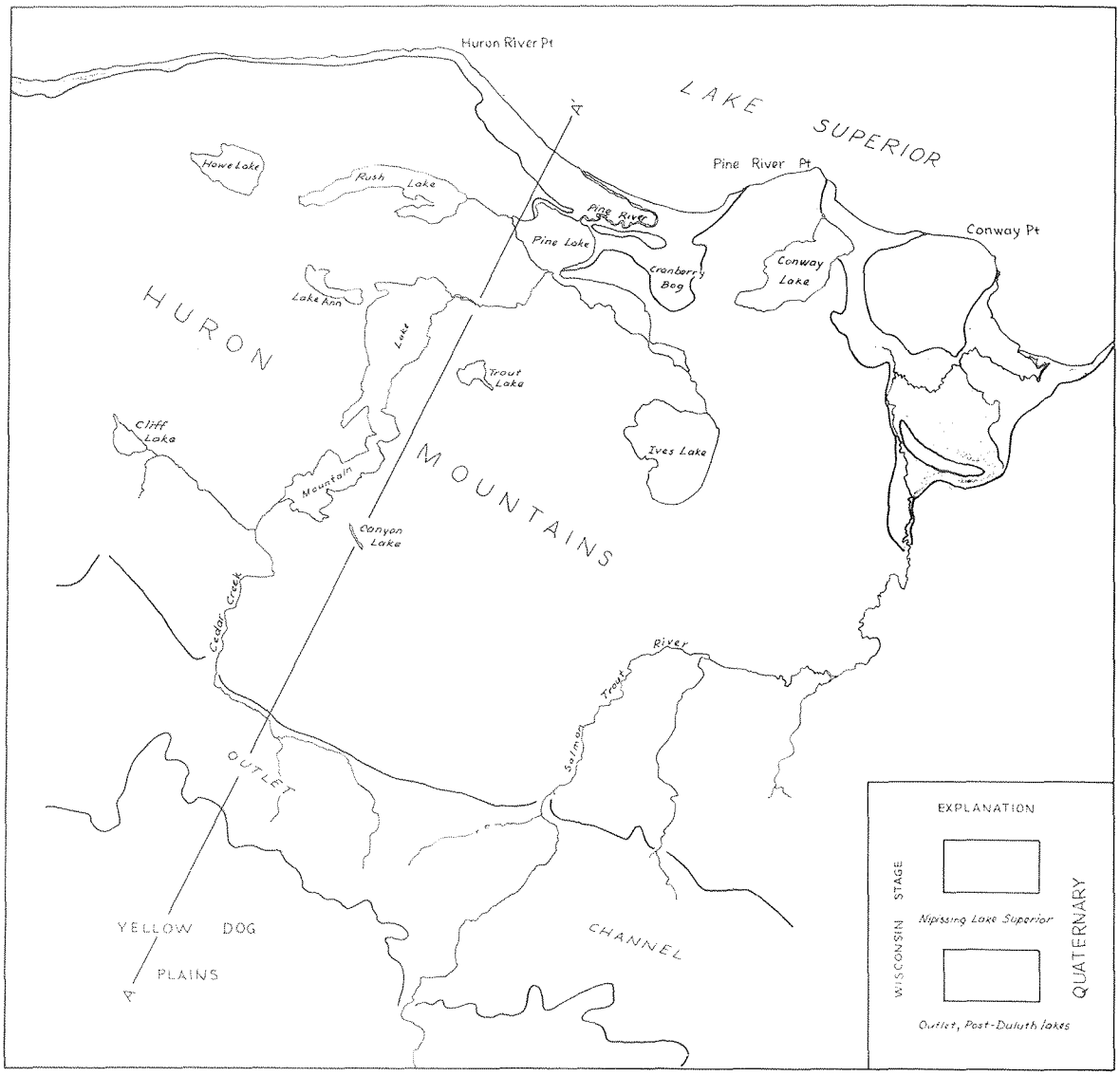
TABLE I

Outline of Lake Superior History

Lake Stage	Original Elevation	Age (yrs ago)	Outlet	Remarks
Lake Superior	602 ft.	<1000	St. Marys River	continued uplift.
Sub-Sault beach	(?)	(?)	St. Marys River	continued uplift.
Sault beach	587(?) ft.	2000	St. Marys River	uplift of Sault.
Algoma stage	596 ft.	3200	St. Marys strait	downcutting at Port Huron.
Nipissing Great Lakes	605 ft.	4100	St. Marys strait	strong shorelines built by rising waters.
Houghton Low Stage	360 ft.	8500	St. Marys River	extreme low level.
Post-Minong beaches	450-360 ft.	9000-8500	straits to Lake Huron	transitional stages.
Glacial Lake Minong	around 450 ft.	9000	straits to Lake Huron	first lake to occupy entire basin.
Post-Duluth stage	1007-650 ft. and lower	9500-9000	Huron Mountains-Marquette area	continuing ice retreat.
Glacial Lake Duluth	1085-1035 ft.	10,000 -9500	Moose Lake and Brule-St. Croix	first large lake.
Epi-Duluth stage	1100 ft.	10,500	Moose Lake and Brule-St. Croix	small marginal lakes.

PLATE I

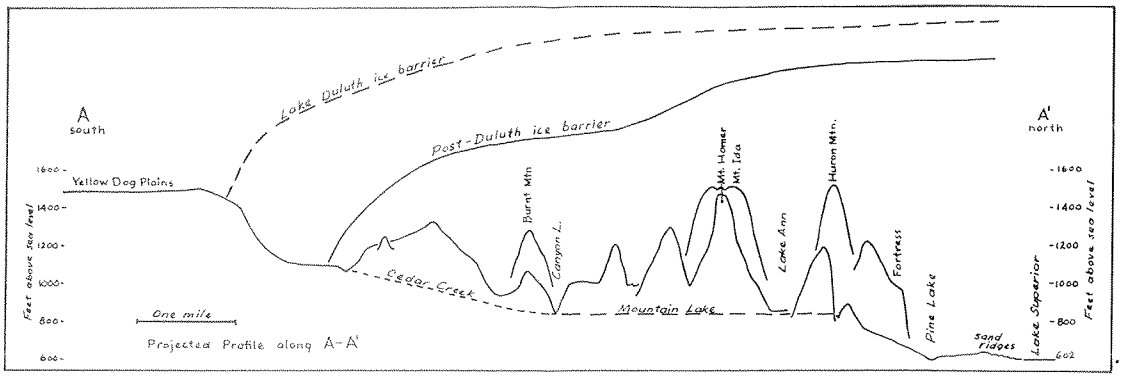


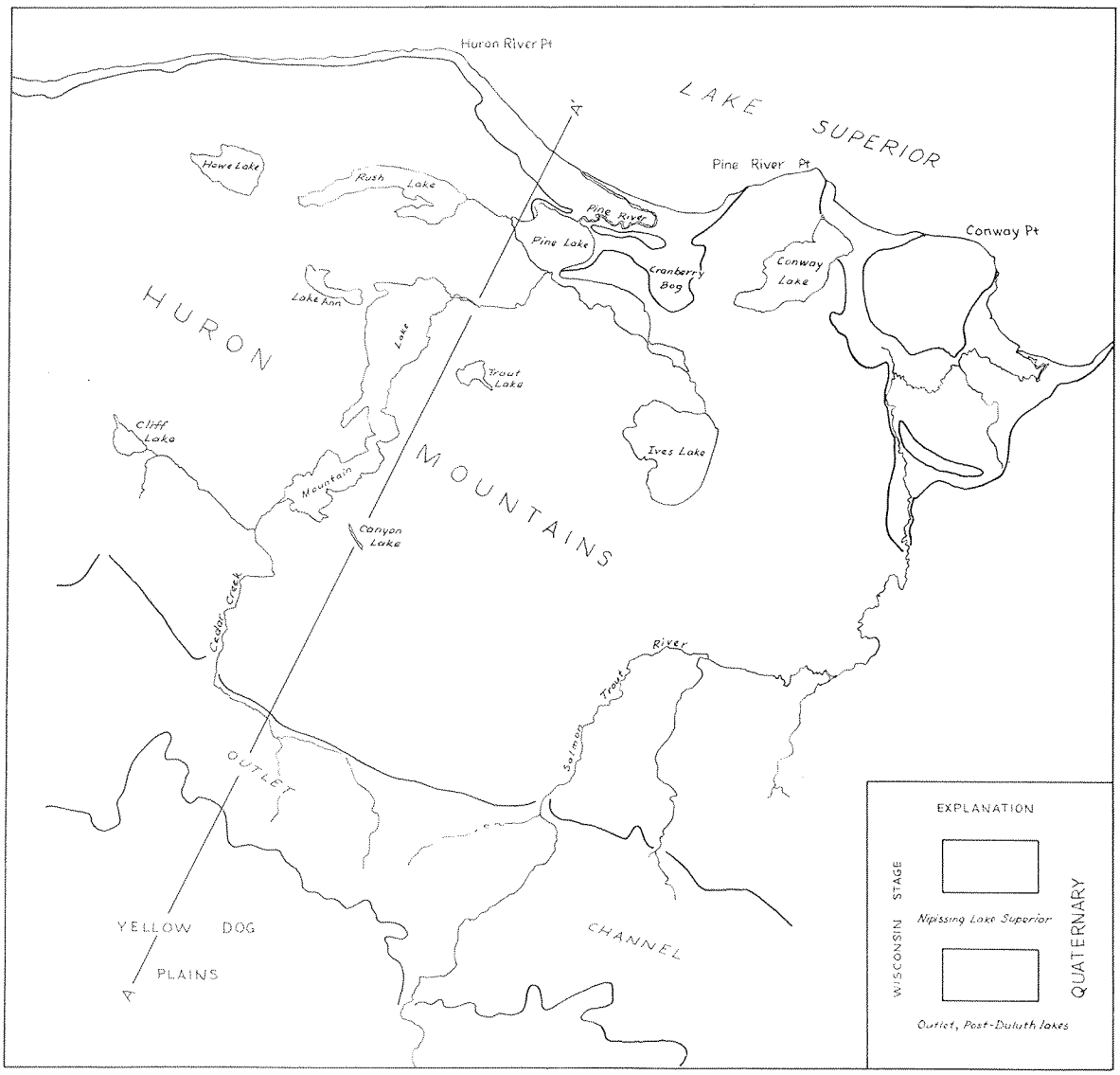


LATE WISCONSIN GEOLOGY, HURON MOUNTAINS
MICHIGAN

Geology by W. Farrand
Base: Huron Mtn, Mich., quadrangle, USGS, 15-min.

PLATE I





LATE WISCONSIN GEOLOGY, HURON MOUNTAINS MICHIGAN

Geology by W. Farrand
Base: Huron Mtn, Mich., quadrangle, USGS, 15-min.