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REVISION OF THE NIPISSING STAGE OF THE GREAT LAKES

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The records of glacial and post-glacial lakes in the Great Lakes region were studied intensively by a number of geologists in the latter part of the nineteenth century and during the first decade of the twentieth century. The results were presented in the United States Geological Survey Monograph 53, by Leverett and Taylor, in 1915. During the next 20 years there were no important contributions to the subject, and the Great Lakes history as presented by Leverett and Taylor came to be widely accepted. Modern textbooks of historical geology give the Leverett and Taylor version of the Great Lakes history.

The first serious revision of the generally accepted history, and one involving the Nipissing stage, was made by Stanley in 1936. Bretz published additional revisions in 1951, and the writer recently has completed a two-year study of various Great Lakes features (Hough, 1953). During the past three years a few radiocarbon dates have been obtained for events in the later lake history (Arnold and Libby, 1951; Libby, 1951; Libby, 1952).

A revision of the Nipissing stage, required by some of the new information, should be of interest not only to geologists but to archeologists, because human occupational sites have been found associated with the Nipissing and related beaches.

The Leverett and Taylor History

In the history presented by Leverett and Taylor (1915), the Nipissing Great Lakes existed as the last generally well-defined stage before the lakes in the Michigan and Huron basins reached their present elevation. In the northern parts of the Michigan and Huron basins and in the southern part of the Superior basin the Nipissing beach is one of the most strongly developed shores of the Great Lakes region. This beach has been tilted by earth movement since it was formed, and it occurs at successively higher levels to the north. Gilbert, in 1898 (p. 605), as well as Spencer and Taylor in their early writings, states that the Nipissing beach descended below present lake level in the southern parts of the Michigan and Huron basins. Taylor (in Leverett and Taylor, 1915) later stated that the Nipissing beach of the north descended to an elevation of about 15 feet above present lake level and extended throughout the southern parts of the Michigan and Huron basins at that elevation. A correlation thus was made between the strong Nipissing beach of the north and a weak beach at an elevation of 596 above sea level in the south.

The Nipissing Great Lakes, according to Leverett and Taylor, were preceded by a complicated series of

Algonquin lake stages which existed while glacial ice stood in the lake basins, forming some part of the northern shore. These stages may be summarized as follows:

Algonquin I, at an elevation of 605 feet, discharged southward both at Chicago and at Port Huron; Algonquin II, at an elevation perhaps as much as 100 feet lower, discharged at Kirkfield, Ontario, to the Trent Valley; Algonquin III, at an elevation of 605 feet (because upwarp of the land raised the Kirkfield outlet), discharged at the old Chicago and Port Huron outlets; "Lower Algonquin" stages formed in the northern parts of the region while upwarp of the land to the north was in progress, but the lake continued to discharge through the Chicago and Port Huron outlets and the lake surface remained at the same elevation (605 feet). Figure 1 shows the Algonquin III beach and the "lower Algonquin" beaches converging to the single Algonquin level in the south, as described by Leverett and Taylor.

The original stage of Lake Nipissing came into existence, according to Leverett and Taylor, when glacial ice retreated from the Mattawa-Ottawa valley and permitted the lake to drain through a new outlet at North Bay, Ontario. This was the "one-outlet" stage, and it stood at an elevation of "530 ±" feet (Leverett and Taylor, 1915, p. 469) or about 50 feet below present lake level. Upwarp of the land to the north raised the North Bay outlet, and the lake surface rose until the water discharged to the south through the old Port Huron outlet. It was assumed that the sill of the Port Huron outlet somehow had been lowered, during the period when no discharge occurred there, from the old Algonquin level to a level which stopped the rising Nipissing waters at an elevation of 596 feet. The main Nipissing stage, or the Nipissing Great Lakes, then remained at that elevation and discharged both at North Bay and at Port Huron. Following this stage the lake surface

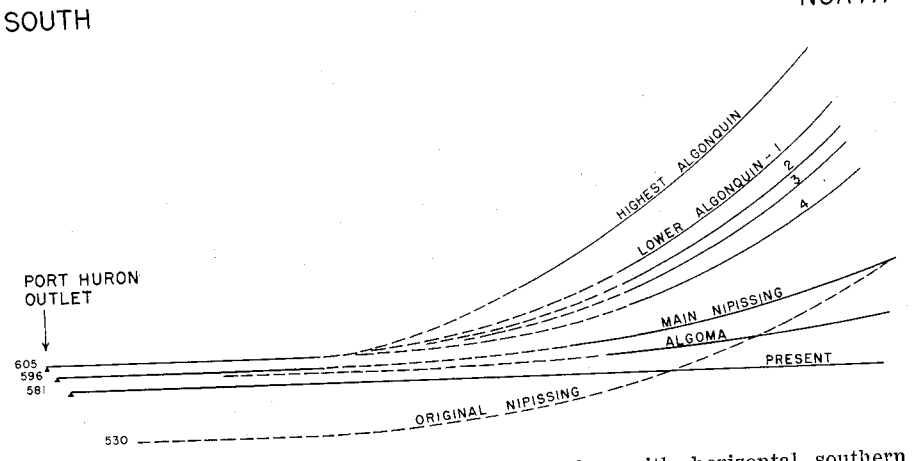

FIG. 1.—Correlation of warped northern beaches with horizontal southern beaches in the Huron basin, according to Leverett and Taylor.

was lowered, by erosion of the Port Huron outlet, to the present elevation of Lakes Michigan and Huron, pausing at intermediate levels long enough to cut the Algoma beach and a few other faint beaches.

Some more recent studies, to be described later, have shown that certain steps in the foregoing history are incorrect. With this knowledge in mind, a critical reading of the Leverett and Taylor monograph (1915) reveals that almost the entire history from the Algonquin to the present synthesized by those authors consists of statements which are not supported by field evidence. The parts of the history which are based on direct field evidence are as follows: Algonquin stage III is represented by a fairly extensive beach, the "lower Algonquin" stages are represented by discontinuous beach features in the north, and the "two-outlet" Nipissing stage is represented by a strong beach in the north and by a weak beach in the south. The various outlets involved obviously were in use at some time in the history. Correlations between northern and southern beaches are questionable, however, and the detailed interpretation of events as presented in this history is not supported by facts.

The Stanley Revision

In 1936 Stanley showed that the "lower Algonquin" beaches of Leverett and Taylor, or their apparent correlatives in the Georgian Bay area, do not converge to the south but are essentially parallel. They descend below present lake level, instead of converging on the "highest" Algonquin beach at an elevation of 605 feet. The Nipissing beach cuts across the "lower Algonquin" beaches. These relationships are shown in figure 2.

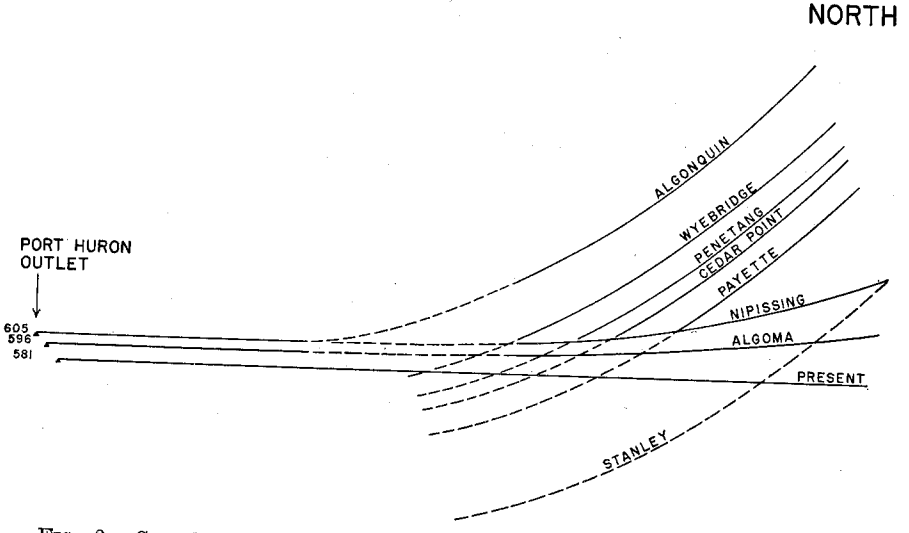

Fig. 2.—Correlation of warped northern beaches with horizontal southern beaches in the Huron basin, according to Hough (modified from the Stanley interpretation).

The logical interpretation of this information is that the lake level must have been lowered by drainage through new, successively lower, outlets and that no appreciable upwarp occurred until after the entire Algonquin series was formed. A further consequence is that when glacial ice retreated from the North Bay area the lake surface may have been lowered nearly to sea level. This is suggested by the relationship of the "lowest Algonquin" (Payette stage of G. M. Stanley) to the highest (main) Algonquin beach; it is parallel and 190 feet lower. The lake surface was lowered from an elevation of 605 feet to 415 feet before upwarp occurred. Stanley suggested that upwarp may have begun considerably later than the Payette stage, and that the lake surface may have been much lower. Stanley then (1938) pointed out a channel in the floor of the Straits of Mackinac, connecting the Michigan and Huron basins, which has a present minimum depth of approximately 150 feet, and calculated that the channel bottom before upwarp was at an elevation of approximately 230 feet, or 350 feet below present lake surface. This means that Lake Michigan may have been at an elevation of 230 feet; Lake Huron may have been still lower, because the channel is recognizable as a feature which extends downward into the Huron basin.

Stanley's work was confirmed by Deane (1950), who likewise found an essential parallelism of the beaches from the (highest) Algonquin down to, but not including, the Nipissing.

One consequence of accepting the work of Stanley and Deane is that the Leverett and Taylor Algonquin stage II (the low-water stage between Algonquin I and III) should be abandoned for a lack of supporting evidence. Algonquin I and III thus merge into a single Algonquin stage. This detail has no immediate bearing on the Nipissing stage, however, and will not be discussed further in the present paper.

Pre-Nipissing Low-Water Stage

The pre-Nipissing low-water stage postulated by Stanley has been confirmed by the writer; coarse-grained sediment and shallow-water organisms were found in the Lake Michigan bottom deposits down to a depth of 350 feet (Hough, 1952). The low stage in the Lake Michigan basin has been named Lake Chippewa. The existence of Lake Chippewa requires a low stage in the Huron basin also, which has been named Lake Stanley in recognition of G. M. Stanley's work.

The Leverett and Taylor hypothetical "original Nipissing" stage occupied a somewhat similar position in the history that Lakes Chippewa and Stanley now occupy. The "original Nipissing," however, was conceived as following the greater part of the post-Algonquin uplift, and the lake surface was stated to be at an elevation of approximately 530 feet. It is proposed that the term "original Nipissing" be abandoned, and that "Nipissing" be restricted to a later stage when the lake surface was raised back to the level of a southern outlet.

Transition to the Nipissing Stage

Following the extreme low-water stage, Lakes Chippewa and Stanley, there was uplift of the land to the

north, warping the old beaches and raising the North Bay outlet. The lake surface was raised until the water discharged to the south, after which no further rise in lake level was possible. This period of rise from the Chippewa-Stanley low levels to the level of the southern outlet is a transitional stage, and the term "Nipissing" is here applied to the stage of static level which followed the transition.

North-South Correlation of the Nipissing Beaches

None of the old beaches in the northern parts of the Michigan and Huron basins can be traced to a junction with any of the beaches in the southern parts of the basins. Erosion has removed all the old beaches above present lake level on both sides of the Michigan and the Huron basins in the critical areas where the tilted northern portions approach horizontality. This fact may be gleaned from the Leverett and Taylor monograph only by very careful study. There is thus no direct field evidence for making correlations between the northern and southern beaches.

As stated in the foregoing summary of the Leverett and Taylor history, Taylor and others at one time had postulated that the generally accepted Nipissing beach in the north, in the warped area, descended below lake level in the south. When Taylor later stated that the Nipissing beach descended from the north to a position of horizontality above present lake level at an elevation of 596 feet, he had no further field evidence on which to base his revision. It appeared to be a more logical deduction in view of his current concept of lake history. With nothing more substantial to support it, Taylor's level for the Nipissing stage is not defensible.

The writer has made a new revision in which the Nipissing beach becomes horizontal above present lake level at 605 feet. This not only appears to be logical in his concept of lake history, and to be a correlation of northern and southern beaches which compare more favorably in strength of development; it is supported by radiocarbon dates obtained for beach materials in both the northern and southern areas. The reasoning which led to the supposition that the Nipissing stage stood at 605 feet, the old Algonquin level, will be summarized before supporting data are presented.

The Nipissing Stage

Resorting to an arm-chair analysis, the writer reasoned that the Nipissing stage should have existed at the same elevation as did the earlier Algonquin stage. This reasoning is as follows: the discharge of the Algonquin stage (Algonquin I and III of Leverett and Taylor) passed through the southern outlets, without cutting them down, for a long period of time during which the strong Algonquin beach was formed throughout much of the Michigan and Huron basins. The outlet channels apparently were stabilized in relation to the discharge of Lake Algonquin, and a greater volume of discharge would be required to initiate downcutting. No source of greater discharge late in the Algonquin stage is known. In view of the work of Stanley, Deane, and the writer it appears that the lake waters

were drained down to successively lower levels, including the Chippewa-Stanley low-water stage, before any appreciable upwarping in the north, and that the drainage was through new lower outlets to the east and to the northeast. The Chicago and Port Huron outlets presumably were abandoned while they were still at the level which had controlled the Algonquin stage.

When the water rose to the Nipissing stage it presumably would have found the outlets at the same elevation they had had when they were abandoned. Because the Nipissing-stage lake drained largely through the North Bay outlet at first, and only slowly sent additional quantities of water to the south (because of the slow rise of the North Bay outlet), the initial cutting power of the Nipissing discharge through the Port Huron outlet would have been less than that of the Algonquin discharge. The strong development of a single Nipissing beach in the north indicates that the Nipissing stage was comparatively long and stable. When the North Bay outlet was raised sufficiently, the entire Nipissing discharge (from all of the upper lake basins) was finally diverted to the south. At this time downcutting of the Port Huron outlet was begun (the Chicago outlet was on bedrock), which terminated the Nipissing stage.

According to the foregoing reasoning, the Nipissing-stage lake occupied the old Algonquin beach in the southern, unwarped portions of the Michigan and Huron basins. This conclusion is supported by a comparison of the generally accepted Nipissing beach of the north, which is a strongly developed feature, with the Algonquin level (605 foot) beach of the south, which also is a strongly developed feature. The beach at 596 feet in the south, which Leverett and Taylor designated as Nipissing, is a much weaker feature and compares more favorably with the Algoma beach of the northern areas, which lies in a position between the Nipissing and the present lake level.

Radiocarbon Dates

When the radiocarbon dates for various beach features in the Great Lakes region (Arnold and Libby, 1951; Libby, 1951; Libby, 1952) are first assembled, they do not fall into a reasonable sequence. The dated events as identified in the original reports are listed below:

	Age in years
Mankato glacial substage maximum	11,000
Lake Grassmere beach (Erie basin, approximately correlative with Toleston beach of Michigan basin	8,513 ± 500
"Toleston level beach" (605 ft.) in Chicago area	3,469 ± 230
Nipissing beach, Lake Superior basin	3,656 ± 640
Nipissing level (594 ft.), Burley site, Lake Huron	2,619 ± 220

If, however, it is assumed that the Nipissing-stage lake rose to the Algonquin level (605 feet), as suggested in the foregoing discussion, and the names of the beaches are adjusted accordingly, the radiocarbon dates fall into the correct sequence:

	Age in years
Mankato glacial substage maximum	11,000
Lake Grassmere beach (Toleston)	8,513 ± 500
Nipissing beach, Lake Superior basin	3,656 ± 640
Nipissing beach ("Toleston level" beach, 605 foot) in Chicago area	3,469 ± 230
Algoma level (594 foot), Burley site, Lake Huron	2,619 ± 220

It is concluded that the Nipissing stage occurred about 3,500 years ago at an elevation of 605 feet above sea level, and that the Algoma stage occurred nearly a thousand years later at an elevation of 596 feet.

Transition From Nipissing to Present

During the lowering of lake level from the Nipissing stage to the present (by downcutting of the Port Huron outlet), there was one well-defined static period, during which the Algoma beach was formed. In the northern areas, where the identity of the Nipissing beach is unquestioned, the Algoma beach is recognized as a lower beach of moderately strong development. It, like the Nipissing, is warped upward to the north, but it rises at a gentler rate. It is this beach that the writer correlates with the 596-foot beach in the southern, unwarped areas.

The cause of the Algoma static period is not definitely known, but a detailed study of the St. Clair-Detroit River outlet channel by Leverett and Taylor (1915, pp. 494-495) provides a possible explanation. It is evident that in comparatively recent time the Detroit River has shifted laterally from a bedrock-floored portion of its channel to a new location on unconsolidated material, and in making the shift has locally increased its gradient. The writer suggests that this channel shift may be related to the Algoma stage. During the lowering from the Nipissing to the present, the outlet channel may have become graded to the temporary base-level of the bedrock section of the channel, and thus have held the lake at the Algoma level. Downcutting began again after the lateral shift, and the gradient of the channel was adjusted to a lower base-level, causing a drop in lake level.

Faint discontinuous beaches between the Algoma and the present levels presumably record brief static periods, but no explanation for these is known.

Discussion of the Burley Site

The date for the 594-foot level at the Burley site (Port Franks, Ontario), near the southeastern shore of Lake Huron, was obtained by radiocarbon analysis (Libby, 1952) of charcoal taken from a site of human occupation. The charcoal was associated with evidences of a prehistoric people in the first or lowest occupational stratum. Two additional occupational strata occur at higher levels and contain records of more advanced cultures (Jury and Jury, 1952). A geological study of the Burley site made by Dreimanis (in Jury and Jury, 1952, pp. 72-75) showed the following section:

Horizon	*Elevation of base above sea level*
g. Wind-blown sand	600
f. Dark sand (3rd occupational layer)	599
e. Wind-blown (?) sand	598
d. Dark layer (2nd occupational layer)	597
c. Stratified alluvial sand	595
b. Dark sand (1st occupational layer)	594
a. Sand	

The approximate elevation above sea level of the base of each horizon is given as calculated by the present writer from data on the elevation of the top of horizon b and the average thickness of the other horizons, as reported by Dreimanis. Dreimanis, following Goldthwait (1910, p. 18) and

Taylor (Leverett and Taylor, 1915, pp. 449 and 459), as most students of Great Lakes history have done, accepted a Nipissing identification for the 596-feet beaches and therefore assigned an early Nipissing age to the dated horizon at 594-595 feet. He stated that the dated horizon (b) was occupied in early Nipissing time, that the lake level then rose to 15 feet above the present level (to elevation 596), and the former living site (b) became flooded and covered by alluvial sand with intercalated streaks and lenses of plant remains (horizon c); then the lake level lowered and the river terrace became inhabited again (horizon d). Apparently wind-blown sand (horizon e) covered the second occupational stratum, a third occupational stratum (f) then developed and this, in turn, was covered by wind-blown sand (horizon g).

The present writer suggests a different interpretation of the Burley site stratigraphic section. The Nipissing stage stood at an elevation of 605 feet, water level then was lowered to the Algoma stage (elevation approximately 596 feet), and after a further slight lowering the Burley site was first occupied. Because the Burley site is on a river deposit a mile from the lake, the alluvium (c) which covered the first occupational horizon (b) could accumulate without requiring a rise in lake level. All subsequently deposited cover appears to be of wind-blown origin.

This interpretation is compatible with the writer's conclusion that the Nipissing stage occurred about 3,500 years ago at an elevation of 605 feet above sea level and that the Algoma stage occurred about 2,600 years ago at an elevation of 596 feet above sea level. The Burley site, therefore, apparently was first occupied during late Algoma time.

Summary

High-water stages preceding the Nipissing are represented by the Toleston beach in the Michigan basin, at an elevation of 605 feet above sea level, and by the early Algonquin beach in the Huron basin at approximately the same level; these were merged into a single lake, the Algonquin stage, at elevation 605 feet, by retreat of the ice from the Little Traverse Bay–Lake Huron lowland. The Algonquin-stage lake discharged at Chicago and at Port Huron.

The Algonquin stage terminated when retreat of glacial ice uncovered a new lower outlet at Kirkfield, Ontario. The lake waters drained down below the level of the southern outlets, leaving them at their Algonquin-stage elevations.

Successively lower lake stages discharging through successively lower outlets followed, until the extremely low Lakes Chippewa and Stanley existed in the Michigan and Huron basins, respectively. These discharged at North Bay, Ontario. Upwarp of the land to the north then occurred, raising the North Bay outlet and raising the water level in the Michigan and Huron basins. When the North Bay outlet was raised to the elevation of the old southern outlets, discharge occurred at three points: North Bay, Port Huron, and Chicago. This initiated the Nipissing stage. The elevation of the Nipissing lake was the same as that of the preceding Algonquin stage, 605 feet above sea level, because its elevation

was determined by the southern outlets which had been abandoned at the Algonquin level.

In the southern half of the Michigan basin three lake stages stood at the 605-foot beach: the Toleston, the immediately succeeding Algonquin, and the post-low stage Nipissing. In the southern part of the Huron basin the early Algonquin, the Algonquin, and the Nipissing stood at the 605-foot beach. Farther north, upwarp of the land raised the older beaches, and the Nipissing beach was formed at a level which cut across the older beaches. Further uplift occurred after Nipissing time, so that the Nipissing beach now also rises to the north but not as steeply as the older beaches. Downcutting of the Port Huron outlet, probably caused by diversion of the entire Nipissing discharge to the south when the North Bay outlet was raised above lake level, terminated the Nipissing stage. The level of the lowering lake was stabilized for a time at an elevation 596 feet above sea level, when the Algoma beach was formed. The cause of this static period is not definitely known, but it may have been because the outlet channel was stabilized on bedrock until the outlet channel shifted laterally to unconsolidated material. Further downcutting of the channel lowered the water to the present elevation of lakes Michigan and Huron.

The Nipissing stage is dated as about 3,500 years old, and the Algoma stage is dated as about 2,600 years old, by radiocarbon analysis.

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