Evidence for an Early Holocene channel connecting the present day Tahquamenon and Manistique Rivers, eastern Upper Michigan, USA

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Abstract

Until recently, geographers believed that over 9,000 years before present, water in early Lake Minong (modern Lake Superior) consistently drained though the Saint Mary’s River into Lake Stanley (modern Lake Huron). With the recent discovery of the Nadoway Barrier, it has been proposed that Lake Minong must have drained to a lower lying area in another location. Locally high elevations surrounded the entire perimeter of early Lake Minong except for in one specific area, Michigan’s eastern Upper Peninsula. It is proposed that a prehistoric channel connecting the present-day Tahquamenon River and Manistique River is a likely link between Lake Minong and Lake Chippewa (modern Lake Michigan). The Tahquamenon and Manistique Rivers are currently separated by seven miles and are 300 feet above the surrounding Great Lakes. Exploration using ground-penetrating radar near the present basin divide shows evidence of prehistoric water flow for a perhaps a few hundred years in the early Holocene Epoch (last 12,000 years). The dating of interior sand dunes and loess (windblown sand accumulations) in the eastern Upper Peninsula also indicates a pattern consistent with the time in question. Further evidence, such as Lake Superior varve and rhythmite correlation and dating, and Great Lake isotopes records suggest unusually high water periods during the collapse of the Nadoway Barrier. Sonar mapping of northern Lake Michigan has also revealed an apparent delta off the coast of Manistique, indicating a water outlet dated around 9,000 years BP. These initial findings require confirmatory landform dating and analysis.
Introduction

The Great Lakes changed their appearance many times during the retreat of the Laurentide Ice Sheet in the early Holocene. Many hydraulic changes occurred when the glacial front reached the northern extent of the Upper Peninsula around ten thousand years ago. Lake Duluth (western Lake Superior) was rapidly advancing eastward, while early Lake Minong was creeping westerly (Saarnisto, 1975). At the time, an ice lobe perched over the center of Michigan’s Upper Peninsula prevented these great glacial lakes from merging. This lobe of ice experienced many local reductions and re-advances. One of the most notable advances was the Marquette Advance during the Younger Dryas, a period identified as being a relatively cold interval between 11,000 and 10,000 years ago. Warming during the following one thousand years reduced the ice sheet out of Lake Minong. This rapid retreat caused the merger of Lake Duluth and early Lake Minong, with associated increased water levels. The geography of the eastern Upper Peninsula over 9,300 BP experienced an abrupt and still largely unexplainable transition. The Saint Mary’s River near present day Sault Ste. Marie was once thought as the main drainage for Lake Minong during this time period, but other evidence suggests differently. Following the retreat, isostatic rebound may have closed the Saint Mary’s outlet, and a drift moraine may have dammed Lake Minong across the Nadoway Barrier (Yu, et al., 2010). If this was the case, Lake Minong would have necessarily drained though another passage. This study examined evidence for an alternative water pathway using surface exploration, computer mapping, and ground penetrating radar. Research questions for this study consist of and are not limited to;

1. To what degree if any, does the current landscape near the basin divide produce evidence of the past channel;
2. When and what caused the basin to split into two separate basins;

3. Geographically where was the spillway located, and;

4. What event caused this spillway to form?

**Literature Review**

Local evidence of Younger Dryas flora was found in 1976 at Lake Gribben (24 km. southwest of Marquette, MI). New land was exposed when a glacial front receded prior to the Marquette Advance, and this area eventually became forested as conditions became favorable for vegetation. Outwash from the subsequent Marquette Advance deposited silts and sands, burying the forest. The tree crowns were then severed by stream abrasion and gravel accumulations as the glacial advance pushed further. The advance would continue and then eventually recede completely with the warming climate in the later Holocene (Figure 1). Carbon 14 dating of spruce logs from the Gribben site, demonstrate a date around 10,025 years BP (Lowell, Larson, Hughes, & Denton, 1999).

During the time the Marquette Lobe was stationary over northern Michigan, water from Lake Duluth drained through the Au-Train Whitefish Channel (Au-Train, MI running to the coast of Wisconsin’s Door Peninsula) emptying into Lake Chippewa (Linebeck, Dell, & Gross, 1979). During this period, early Lake Minong drained though the Saint Mary’s River into Lake Stanley. As the Marquette Advance receded, water from Lake Duluth could drain through channels to early Lake Minong.
Figure 1. The Lake Gribben chain of events; A.) Retreating glacial front, B.) Forest growth, C.) Re-advancing glacial front (Marquette Advance), D.) Burial and severing of tree tops by sand and silt, E.) Retreating glacial front leaving a buried forest (Lowell, Larson, Hughes, & Denton, 1999).
These bedrock channels formed on the margin of the glacial front and the surrounding landscape and can be viewed today in the Chapel area, Beaver Basin, and near Grand Marais in the present day Pictured Rocks National Lakeshore region (Figures 2-3). This series of drainage ways linked a string of lakes along the glacial front, some of which are still remnant. Today, these areas are now abandoned kame terraces (stair step-like features) mainly composed of gravel and sand (Blewett, 2009). It is possible that the Au-Train Whitefish Channel to the west may have been abandoned as channelized flow carved deeper into the Pictured Rocks margins. This would have resulted in Lake Duluth feeding Lake Minong with its drainage, instead of Lake Chippewa to the south.

Figure 2. Bedrock channels cut into Pictured Rocks National Lakeshore during the receding of the Laurentide Ice Sheet. Channelized flow can be viewed flowing from Lake Duluth to early Lake Minong (West to East). Pictured Rocks National Lakeshore.
Figure 3. Abandoned kame terraces near Grand Marais, MI (Blewett, 2009)

While the Laurentide Ice Sheet fully receded to the northern extent of the Lake Superior basin around 9,500 years BP, glacial melt water was accumulating in Lake Minong (a coalesced Lake Duluth and early Lake Minong). Water levels of Lake Minong would gradually rise and stabilize at around 225 meters (738 feet) above sea level. This level is respectably higher than today’s current lake level of Lake Superior, which is 183 meters (602 feet). With the rise in lake levels, lower inland areas were flooded and quickly transitioned into beach environments. Many of the southern low-lying inland areas had been flooded before by Lake Algonquin (over 10,500 years BP), while the northern Upper Peninsula may have still been covered by the glacial front (Farrand, 1988). During Lake Minong’s rise, many dunes formed across the eastern Upper Peninsula of Michigan with large accumulations notable in Schoolcraft, northern Luce, and northern Chippewa counties. Large series of these dunes were dated by Loope et al. (2010) who
defined the Lake Minong shoreline and its lake level changes (Loope, Loope, Goble, Fisher, Jol, & Seong, 2010). Many of the inland dunes were dated between 8,800 and 10,200 years BP. These older dune ages are thought to be related to fluctuations of Lake Minong prior to the Nadoway event. Other samples have suggested that Lake Minong could have risen several meters before falling. The younger records are under speculation, as to how sand accumulations were deposited (Loope, Loope, Goble, Fisher, Jol, & Seong, 2010). The region around 9,000 years BP might have experienced heavy drought or even fires, which may have reduced vegetation cover, allowing sand to transport more readily (Loope, Loope, Goble, Fisher, Jol, & Seong, 2010). Loess (wind-blown silt) deposits are also prevalent in some of the uplands throughout the study area. This local process has been linked to the winds that carried silt from lakebed deposits. The loess generation model (Figure 4) demonstrates how coarser and heavier deposits (sand) remained in the lake bottom as dunes, while finer and lighter deposits (silt) were effectively transported to nearby uplands by winds, producing silty caps in areas.

Figure 4. Above: Prominent silty caps on upland areas in Luce and Chippewa counties, Below: Loess Generation Model (Schaetzl & Loope, 2008).
One of the most prevalent and thickest accumulation spots for these silty caps, is along the Tahquamenon upland (former island). These silty caps were likely formed after the fall of Lake Minong and possibility Lake Algonquin, where lake bed deposits were abundant in a vast low lying area to the southwest (Schaetzl & Loope, 2008). This lower lying area spanning from western Chippewa County across southern Luce County, and into eastern Schoolcraft County was filled with water during the rise of Lake Minong. Many islands would have formed within the area, where upland reaches were prevalent, when Lake Minong’s water level stabilized at 225 meters. A narrow channel opening near present day Tahquamenon Falls State Park would have fed the embayment with water from Lake Minong.

Knowing that Lake Minong was generally surrounded by steep topography, aside from a few key areas, helps narrow down possible drainage locations. Possibilities include the Au-Train Whitefish Channel, a northerly drainage through Ontario into the Hudson Bay, and the proposed Tahquamenon-Manistique Channel in the eastern Upper Peninsula. For a northerly drainage through Ontario to be plausible, a subsurface glacial stream through the Laurentide Ice Sheet would have had to be present. The Au-Train Whitefish Channel serving as the drainage of Lake Minong during the presence of the Nadoway Barrier is probable, but if it was abandoned during the time of the Pictured Rock bedrock channels, it is very unlikely to have been reestablished after local rebound. The large embayment spanning well within the interior of the eastern Upper Peninsula during the Minong high, may have been the source of a temporary channel connecting Lake Minong and Lake Chippewa. A study using seismic refraction of northern Lake Michigan’s lake bottom noted a deep basin that coincided with a southwestern bulge at around a 50 m depth (Safarudin & Moore, 1998, Figure 5).
Figure 5. The Manistique Fan located directly South of the Manistique River, suggesting a more channelized flow in the past. (Safarudin & Moore, 1998)

The bulge lies directly south of the mouth of the Manistique River and may represent fan deposition from a more channelized system flowing off the Upper Peninsula (Safarudin & Moore, 1998). This finding maybe the proof needed to validate the possible scenario of the Tahquamenon-Manistique Channel. Since Lake Chippewa was at a lower elevation 230 feet (70 meters) compared to its present Lake Michigan elevation at 581 feet (177 meters), the proposed channel would have extended past the mouth of the present Manistique River. A delta/fan would have formed under what is now northern Lake Michigan, much like the Safarudin and Moore study has identified.

While the Nadoway Barrier (271 meters above sea level) was acting as a dam in southeastern Lake Minong around 9,300 BP, rising waters were an imminent threat for its destruction. A continually melting glacial front over northern Ontario was supplying the basin with more melt water and possibly starting to expose a catastrophic series of events.
Glacial Lake Agassiz once covered as much as 440,000 square kilometers over present-day Manitoba, Ontario, Saskatchewan, and northern Minnesota and North Dakota (Geostrategis, Figure 6). The immense glacial lake was formed around 30,000 years BP and had continually grown in size as the glacial retreat filled its basin with meltwater. During the time in question for this study, Lake Agassiz was at its peak in size and volume, having found drainage during different time periods to the northwest though the Athabasca River, the south through the Minnesota River, the east through the Ottawa River, the north through the Hudson Bay, and eventually the southeast through Lake Minong (Figure 7). The continually northerly melting Laurentide Ice Sheet had now exposed the growing Lake Agassiz to the lower elevated Lake Minong. It is proposed that this breach happened in the northern part of the Lake Minong basin near present day Lake Nipigon, which then catastrophically filled the lake with immense amounts of water. This profound change in additional water introduced to Lake Minong may have been the reason for the Nadoway Barriers collapse. Sapping, or a larger breach, most likely led to a total failure of the barrier. The breach of the sandy moraine dam may have occurred rapidly, maybe even within a year according to records showing a substantial reduction in stable isotopes in Lake Huron which would have received the massive influx of water after the incident (Yu, et al., 2010).

Figure 6. Lake Agassiz and its drainages (Geostrategis)
This massive incursion of water from Lake Agassiz into Lake Minong can possibly be viewed through varve (annual layers of sediment) and rhythmite (sediment layers laid down with regularity) stratigraphy throughout present day Lake Superior (Breckenridge, 2006). Lakebed cores were taken in many locations throughout the Lake Superior basin, so their sediment records could be observed and recorded. These sediments are deposited in layers from tributary sediment inflow, which reveal annual or seasonal temperature variations. Rhythmite records in the western part of Lake Superior recorded around 200 plus rhythmites, compared to the 100 which were found in the Caribou Basin, near the deep center of Lake Superior. The Caribou Basin recorded fewer rhythmites because the area experienced glaciations for an extended amount of time compared to the area to the west, which emerged earlier as Lake Duluth (Breckinridge, 2006). Though these areas experienced different amounts of layering, some records do correlate with each other. A series of 36 thicker than normal varves were recorded near the top of both rhythmite sequences (Figure 8), suggesting a higher than normal sediment flux than normally experienced, possibly Lake Agassiz discharge (Breckenridge, 2006). The existence of these
patterns in Lake Superior, provide a consistent record which can be viewed as annual deposits (36 varves and equivalent to 36 years). The rhythmite accumulations in Lake Superior are sensitive to temperature and/or precipitation patterns and are composed of almost entirely clay sized particles (Breckenridge, 2006). It is suggested that throughout the ice covered winter months, sediment rates slowed significantly and finer grained material would have been deposited, compared to larger grained material in the summer months (Breckenridge, 2006). These varves were roughly dated at 9,350 years BP, which indicates that these layers may be linked to the Lake Agassiz event breaching the Nadoway Barrier.

Figure 8. A.) Rhythmites found in the Caribou Basin, B.) Thin rhythmites which dictate, C.) The thicker rhythmites possibly associated with Lake Agassiz. (Breckenridge, 2006)

When the Nadoway Barrier failed at around 9,300 years BP (whether from Lake Agassiz or not) massive amounts of cold freshwater were released into most of the Great Lakes. The upper Great Lakes have recorded abrupt negative shifts in stable isotopes (indicators of temperature) around the time period of 9,300 years BP (Yu, et al., 2010). Large drops in stable isotopes are evident in Lake Michigan and Lake Huron, indicating there are must have been drainage channels connecting Lake Minong to Lakes Chippewa and Stanley (Figure 9).
Figure 9. Large drops in stable isotopes are noticed in Lakes Michigan and Huron around 9,300 BP when Lake Agassiz likely breached Lake Minong (Yu, et al., 2010).

Figure 10. (Left) Freshwater entering the Atlantic at 9,300 BP, (Right) Present day entering freshwater. (Alley, 2007)

It is estimated that when this substantial freshwater accumulation entered the salty Atlantic Ocean, widespread cooling took place throughout the Northern Hemisphere, up to $-2^\circ$C (Figure 10). This would have led to widespread climate change and possibly a small glacial advance in extreme northern latitudes in present day Canada and Russia. The later Holocene would gradually grow warmer after 9,000 years BP, leading to the Laurentide Ice Sheets abandonment of mainland North America around 5,000 years BP.
Isostatic rebound would raise elevations of previously glaciated areas (still rebounding to this day), which in turn gradually changed the Great Lakes topography. During this time period Lake Minong lowered, while Lakes Chippewa and Stanley rose to its Nipissing level, of around 605 feet above sea level (slightly higher than today). Lake levels of Lake Michigan and Huron would fall near to their present day level by 2,000 years BP, while Lake Superior would fall slightly below today’s present lake level, but then stabilize later at 602 feet above sea level (Farrand, 1988).

**Methodology**

This study utilized the computer program ArcMap in conjunction with digital elevation models (DEM’s) to identify topographical evidence for changing lake levels. This proved useful when searching for possible spillway locations in the western extent of the prehistoric embayment. Multiple maps were created using information from past lake levels, well log data, and soil classifications. USGS Ecologist Walter Loope assisted in physically evaluating the current basin divide, the landscape, and parent material and bedrock abundance. Ground penetrating radar (GPR) was also used in Danaher, MI to identify subsurface features. Future GPR trips are being scheduled to analyze the stratigraphy of sediments in multiple places west of Danaher. This will produce an image of the areas presumed geologic past and may generate evidence for a possible spillway. Well logs were also collected and analyzed throughout Luce, Mackinaw, and Schoolcraft counties.

**Results**

Field surveys were completed near the present day basin divide of the Tahquamenon and Manistique Rivers. GPR was used to explore the embayment and its greatest western extension on County Road 421, near the current basin divide of the Manistique and Tahquamenon Rivers.
Differences between layers may be the possible boundary of different glacial lakes or changing water level events (Figure 12). In the subsurface image three main areas were noticed;

1. A deep wide deposit, which may be evidence of Lake Algonquin or post dated sediments (Blue);
2. A overlying wide deposit, which could be the embayment from Lake Minong (Salmon), and;
3. A thinner deposit which only covered half of the coverage area; this is an alluvial fan (Light Green).

The result of the study produced a picture of the areas geologic past, recording 23 noticeable deposited layers in the Lake Minong segment. These 23 (maybe more) positively identified GPR layers may also be related to the 36 thick varves found in Lake Superior. This finding suggests that water from Lake Minong pressed further to the west toward present day Germfask, MI, where it likely was blocked by local rock outcrops (Figure 11). Terraces are also noticed when viewing a cross section of McMillan, MI at the Minong level, showing that wave erosion occurred. Another indicator of this water level is suggested through a carbon date from a piece of timber removed from a core from the bottom of Kaks Lake (5 miles southwest of Newberry, MI). The sample was dated at around 9,300 BP, which is the suggested time of Lake Minong’s high.
Figure 11. The Minong Embayment, Kaks Lake, and the McMillan cross section.
Figure 12. GPR; Blue = Possible Lake Algonquin stage, Salmon = Lake Minong stage, and Light Green = Alluvial Fan.

Figure 13 shows the area that was examined by the GPR. The alluvial fan that was identified in the GPR scan can clearly be distinguished as a circular deposit laid in a southerly orientation. The alluvial fan postdates the Minong deposits because it has laid down sand on top of the underlying sediments (Figure 12). This indicates that the Tahquamenon River which presently diverts to the east where it approaches the alluvial fan, must have flowed straight south into the lower lakebed for a substantial amount of time. This area is extremely marshy below the higher topology to the north, which is extremely sandy (a result of glacial outwash). Since the uplands are exceptionally sandy, the headwaters of the Tahquamenon River consist of very high concentrations of the very same parent material (Figure 14).
Figure 13. Looking Easterly on an alluvial fan deposited from sandy uplands by a pre-historic Tahquamenon River. (Google 2011)

Figure 14. The sandy Tahquamenon River north of Danaher, MI. (Photographed by author)

The GPR results from Danaher, MI imply that the Lake Minong embayment extended further to the west than the current basin divide (into the Manistique River basin). A likely
location for a spillway is near Germfask, MI. This area has several factors that suggest a possible spillway could be evident to the northeast. A peat/muck soil classification is widely apparent throughout the eastern Upper Peninsula and mimics the 225-meter water level of Lake Minong. This peat/muck could be the remnant of Lake Algonquin and Minong’s lakebeds. The western extent of this peat/muck classification stops in a narrow spot in the topography to the northeast of Germfask (Figure 15), hinting that this area is a possible location for the cessation of the embayment. A reason for the blockage of the body of water may be bedrock, which appears fairly shallow throughout the Germfask area. Wells that recorded bedrock at a depth of 5 meters or less were plotted on a map of the area (Figure 16). Shallow bedrock is evident in the same area northeast of Germfask and fully extends past the narrow straights. This makes the chance of bedrock being a possible dam for the embayment plausible. These three factors work towards a probable situation for a possible spillway, which would then lead to channelized flow into Lake Chippewa. The Manistique River to the northeast of Germfask is considerably deep, wide, and mucky (Figure 17). Coincidently, the river becomes more rocky and shallow as it progresses to the southwest past the likely spillway (Figure 18). Exposed bedrock was not noticed through a 10-mile stretch of river from 10 Curves Park to the Seney National Wildlife Refuge.
Figure 15. Peat/Muck Classification in correspondence with the Lake Minong level.

Figure 16. Bedrock distribution near Germfask, MI.
Figure 17. Manistique River northeast of Germfask. (Photographed by author)

Figure 18. Manistique River southwest of Germfask. (Photographed by author)
Possible Channels near the Proposed Spillway
Discussion

Most recent data supports the possibility of the Tahquamenon-Manistique Channel in the early Holocene setting. Soil classifications and bedrock depths are located in appropriate locations for a spillway, which would likely end near Germfask, MI on the western extent of the Minong embayment. GPR records from Danaher, MI shows that water likely passed through the area and pushed westward. These data indicate that the embayment pressed further west than the present day basin divide and also points to a westerly spillway. The current Manistique River near Germfask is fairly deep and has more abundant rock accumulations downstream from Germfask. No exposed bedrock was found to support this hypothesis, but we did not search for shallow bedrock accumulations beneath the surface. The alluvial fan found in Danaher suggests that the headwaters of the Tahquamenon River once flowed southerly rather than easterly. This is supporting evidence that this stream once flowed in the embayment or the lowland postdating the Minong level. Evidence for the Manistique Delta and reduced stable isotopes in Lake Michigan during the time in question, supports the contention that water from Lake Minong did enter Lake Chippewa, possibly from this location for some amount of time. This channel most likely was established and used as a Lake Minong drainage for a few hundred years, then was abandoned shortly after the Nadoway event. This abandonment combined with isostatic rebound, may have been the bases for the development of the current basin divide between the Tahquamenon and Manistique Rivers. While not conclusive regarding the existence of a Tahquamenon-Manistique Channel, our findings are supportive of this contention, and have increased understanding of geologic features and processes in the eastern Upper Peninsula during the early Holocene.
References


