A Re-interpretation of the Great Lakes Outlets During the Holocene

Terry W. Noble, Environmental Consultant, Thunder Bay, Ontario, Canada (2004)

ABSTRACT

This paper builds on a theme presented in three previous papers (Noble, 2003a, 2003b, 2003c), namely, shifts of the Earth's equatorial axis, relative to its orbital plane, shaped the hemispheric surfaces rather than continental glaciation. Given a major 'disconnect' between the earth's land surface and its oceans, these shifts were responsible, not only for a majority of the planet's morphological evolution but were also a major factor in the evolution of its plant and animal species. This paper is one element of a larger one in preparation that uses the concept to re-interpret water levels in the Northern Hemisphere in general and Canada specifically, during the transition from the Pleistocene through much of the Holocene epoch. A lake level, postulated to have occupied the Red River valley about 10000 years ago, is used as a benchmark to challenge the literature's depiction of various water level scenarios in the Great Lakes. While a previous paper centred on events in the Lake Superior basin, this paper pertains to the changing relationships that existed between the Lakes Huron, Michigan and Erie basins shortly before and after 10000 BP. Of specific interest is the relationship between the Chicago, Port Huron and Fort Wayne outlets, given the controversy surrounding them in the research literature. As with the previous papers, the concepts of isostatic rebound, curved shoreline profiles and continental glaciation are questioned.

INTRODUCTION

This paper builds on a theme presented in three other papers (Noble, 2003a; 2003b; 2003c). The events described in those papers are summarized below for readers encountering the presented concept for the first time. I previously postulated (Noble, 2003a) that a major inundation of water truncated older, more steeply tilted shorelines in the Northern Hemisphere roughly 7600 to 7800 years ago and referred to this event as the Nipissing Transgression. The tilt of this shoreline, relative to both older and modern levels, was used to show that a distinct "disconnect" exists between the earth's landmass and its oceans. This disconnect negates the concept of continental glaciation, which science has erroneously followed for over 160 years. Instead, the Earth's equatorial plane shifts relative to its fixed orbital plane around the sun. In so doing, water and sea ice shaped the Northern Hemisphere's terrain as its landmass passed through the polar region, not advancing and retreating continental ice sheets. These shifts dictated the distribution, hybridization and disappearance of plant and animal species as well as the collapse of many human cultures.

The same paper described the literature's erroneous depiction of the Nipissing freshwater level in the upper Great Lakes as a curved shoreline profile. Researchers mistakenly join the emergent shoreline of an older steeply tilted level in the basin's northern part with the shoreline of a younger, less steeply tilted level in the southern part. The older, upper section of the profile represented a large embayment created by an influx of seawater over the North Bay sill in 7800 BP. Researchers inadvertently connected this level with the lower portion of a younger shoreline profile that formed when the North Bay and Port Huron sills achieved the same level forming a large freshwater lake about 6000 BP. Connecting the two shoreline segments produced an erroneous curved profile that led to the mistaken depiction of the Nipissing event and, accordingly, an inaccurate chronology of water levels in both the upper and lower Great Lakes basins that spanned thousands of years. This same 7800 BP seawater event was described as submerging the Hudson Bay Slope to the extent that, in passing over the Cross Lake sill, it inundated the Lake Winnipeg basin as far as Hecla Island.

PROTO-LAKE WINNIPEG

Using the Red River valley (Fig. 1), the second paper (Noble, 2003b) stepped back 2200 years from the Nipissing Transgression to roughly 10000 BP to further dispute the concept of isostacy and the use of curved shoreline profiles to represent it.

Figure 1. Map of the Red River valley showing the southern extent of the two-outlet phase of proto-Lake Winnipeg (the northern portion to Cross Lake is not shown due to truncation by later levels).

Raised shoreline profiles with opposing tilts were offered as evidence that the Earth's equatorial plane changes drastically relative to its fixed orbital plane. This depiction contrasts with that of the research literature's wherein the various Agassiz levels purported to have affected the Red River valley owed their existence to the sequential opening of lower outlets as the water body followed the glacial ice-front northwards. The set of curved, tilted shoreline profiles in

Figure 2 are typically used in the literature to portray the ephemeral nature of Lake Agassiz, its lowering outlets, the retreating ice-front and the affects of isostatic rebound. Again the steeply tilted part of the profiles supposedly represent maximum uplift due to crustal rebound after the ice sheet disappeared. Areas most recently covered by ice are, purportedly, still rebounding while older areas are not, or minimally so, which produced curved shoreline profiles.

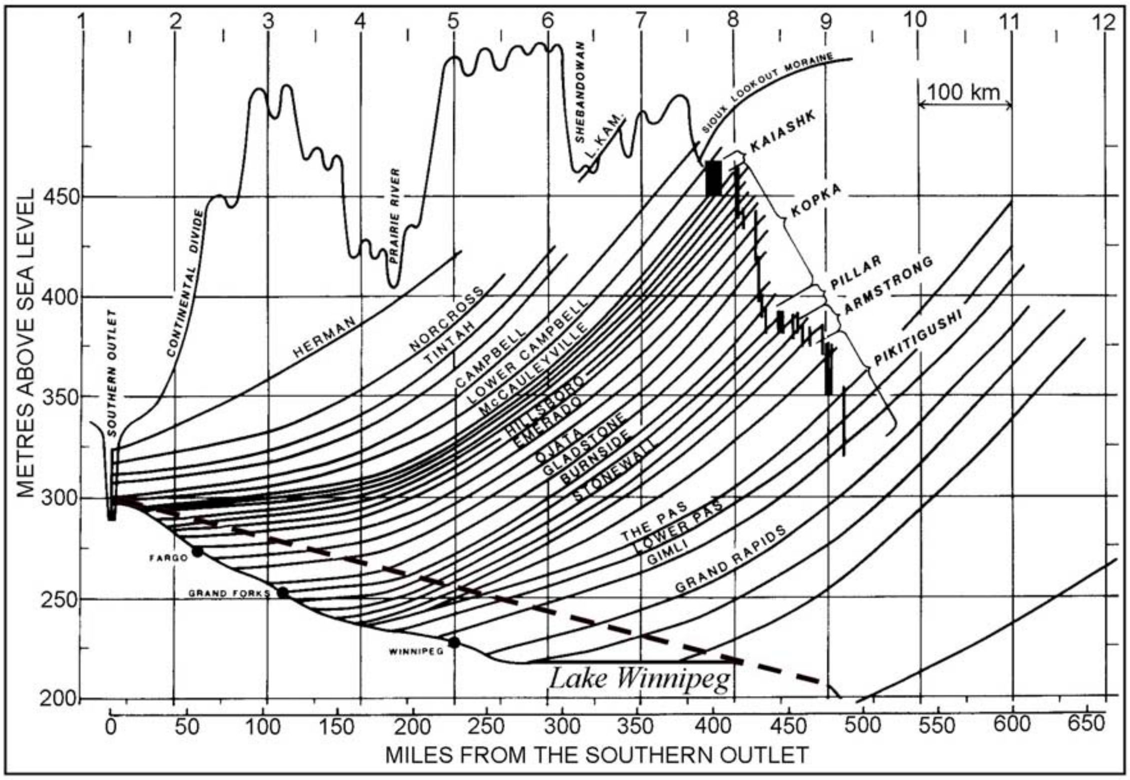

Figure 2. Curved, tilted water plane profiles typically used to depict the Agassiz levels (after Teller and Thorleifson, 1983). The superimposed dashed line is this paper's proto-Lake Winnipeg level.

Curved profiles consist of three parts: a flat, or slightly upward tilting section indicating minimal rebound; a curved central part (the axis); and a steeply tilted, rapidly rebounding upper segment. This concept, and the mistaken identification of outlet sills associated with particular water levels, misconstrued the planet’s evolution prior to and during the Holocene. The confusion relates to the wrongful linking of older tilted shorelines at one end of a basin with emergent younger ones at the opposite end, which produced erroneously curved shoreline profiles. Their curved nature, which, in theory, was indirectly due to continental glaciation or, minimally the delayed response to glaciation, is now used to prove that continental glaciation actually happened. This reasoning is circular at best, given that one of the argument’s constituent elements (i.e., curved profiles) is wrong.

The glacial Lake Agassiz concept has two problems that have existed since the research of Dawson (1875) and Upham (1880, 1890). There is widespread disagreement as to when Lake Agassiz occurred. There is also a well-documented peat layer with an overlying layer of silty clay in the Red River valley portion of the basin that cannot be accounted for by the present Agassiz chronology involving glacial advances and retreats. The Agassiz paper (Noble, 2003b) described a lake, proto-Lake Winnipeg (the Lake Traverse-Cross Lake level), that occupied the

Red River valley about 10000 BP that accounts for the silty clays overlying peat. The dashed line superimposed on the literature's curved Agassiz shorelines in Figure 2 represents that paper's freshwater lake that extended from the Lake Traverse-Mud Lake sill in the south to the Cross Lake sill in the north. The lake began when the northern sill emerged from polar seawater. Initially it was not unlike Lake Winnipeg today, however, as the northern sill rose and the Lake Traverse-Mud Lake sill fell simultaneously, an enlarging proto-Lake Winnipeg backed up the Red River valley to briefly achieve the two outlet Lake Traverse-Cross Lake water level about 9900 to 10000 BP. In so doing, the water truncated older, more steeply tilted shorelines. It also backed part way up the Assiniboine River valley to flood into the south half of the Lake Manitoba basin. The Lake Traverse-Mud Lake sill ultimately captured drainage duties at which time the Red River system flowed southward. Although not strictly 'stream capture' through headwater erosion, it is an excellent example of the Mississippi system taking the extremely large Lake Winnipeg watershed area away from the Arctic Ocean's Hudson Bay Slope.

PROTO-LAKE SUPERIOR

About 10000 BP the ice-front supposedly retreated north across the Lake Superior basin into northern Ontario where it halted and then rapidly re-advanced back to the basin's south side (Hughes and Merry, 1978; Farrand and Drexler, 1985). This, the Marquette Re-advance, apparently impounded small short-lived lakes at either end of the basin that ultimately merged to form Lake Minong when the ice again backed away from the basin's south slope. The Minong emergent shoreline is sharply defined on the north side of the Superior basin, however, contrary to the literature, I don't believe the Marquette Re-advance happened. In my view the Minong level predates what actually occurred in the Lake Superior 10000 years ago by roughly 400 to 500 years (Noble, 2003c).

Researchers since at least Lawson (1893) portray emergent shorelines on the Superior basin's south side as horizontal or, minimally, slightly bent upwards to the north and increasingly so as one moves northeast beyond theoretical hinge lines. The rational for this has been increased isostatic rebound as one moves north. My research indicates that when the proto-Lake Winnipeg basin tipped southward to ultimately drain over the Lake Traverse-Mud Lake sill, the lake Superior basin was concurrently tipping towards its southwest end (i.e., Duluth) as it is today. When the shift ceased, roughly 9700 to 9900 years ago, a proto-Lake Superior level was established, whose shoreline is now only emergent on the basin's south side. Contrary to the literature's depiction of shoreline profiles on the south side of the basin as horizontal, or tilted slightly upwards to the north, this level's profile now tips down to the north. In forming, it truncated many older levels including the above-mentioned Minong level. Due to subsequent axial shifts the highest point for this proto-Superior level is a former embayment associated with what is now a meander of the St. Louis River in Jay Cooke State Park southwest of Duluth. From here it trends downward to the north to just beyond the mouth of the Track River northeast of Grand Marais where it was later truncated by younger levels over the next few thousand years (Fig. 3).

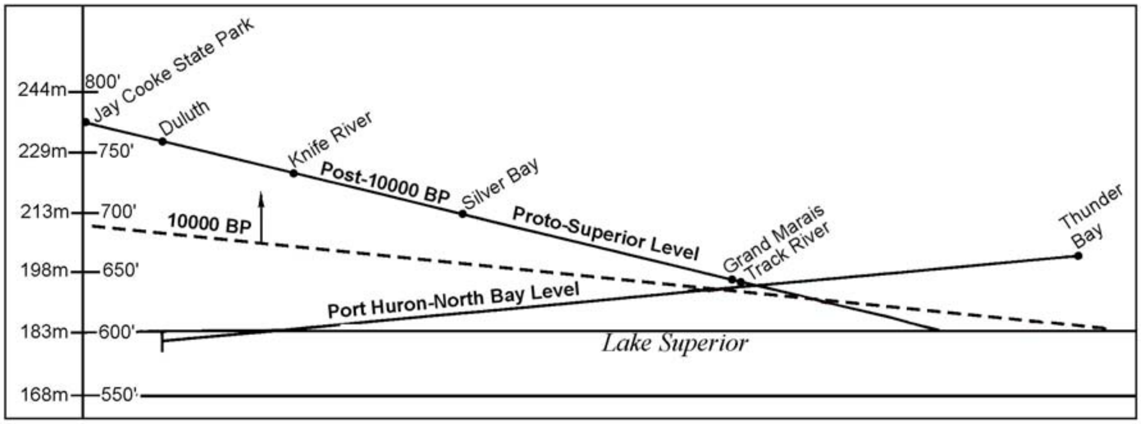

Figure 3. Postulated Proto-Superior level, which now tips down towards the north from Minnesota's Jay Cooke State Park on the St. Louis River to beyond Grand Marais where it was truncated by later water levels that tip down to the south and are only emergent on the basin's north shore.

THE CHICAGO-PORT HURON-FORT WAYNE-FORT ERIE PROBLEM

Building on the foregoing papers, this paper disputes the literature's depiction of water levels in the Lakes Huron, Michigan and Erie basins in the period roughly spanning 9700 to 10000 BP. Given this position it is axiomatic that the literature's portrayal of events, both before and after this period, is questionable. The relationship between the Huron, Michigan and Erie basins, and the many water bodies that occupied them, is complex. The Lake Erie basin, being further south, reputedly held the oldest water body related to the ice sheet retreating north and, ultimately, the sequential opening of lower outlets. The oldest level, Lake Maumee, supposedly existed in the basin at about 14500 BP (Calkin and Feenstra, 1985). Like the literature's Lake Agassiz scenario, this lake was somewhat ephemeral as its level dropped in response to lower outlet sills that opened with ice retreat. Many other lake levels evolved (e.g., Arkona, Whittlesey, Warren, Wayne, Grassmere, Lundy, Early Algonquin, Main Algonquin, the suite of post-Algonquin levels) as the ice-front continued its oscillating retreat across the Huron and Michigan basins. The Nipissing/post-Nipissing scenario would supposedly evolve long after the ice sheet passed over the height-of-land into the Hudson Bay Lowland.

Events in the three basins have been controversial regarding till descriptions; the sequence and timing of various ice advances; and the association of sills and beaches with specific water levels. Most problematic is the suite of beaches purported to relate to the Arkona levels. Controversy aside, the various water levels in the three basins are depicted with curved shoreline profiles that are initially horizontal, or nearly so, at the south end of the basin and ultimately tilt steeply upward to the north. Figures 4, 5 and 6 typify such profiles. Intrinsic to the literature's scenario is that, at a much-debated point in time, three outlets, namely Chicago, Port Huron and North Bay, achieved the same level producing the confluent 'Nipissing' phase in the Upper Great Lakes. Dates for this event occupy a range of roughly 2500 years centred on the middle Holocene. Supposedly uplift (i.e., isostatic rebound) of the North Bay sill allowed water to back up until all three outlets operated simultaneously (i.e., the three outlet phase). Continued uplift led to the abandonment of the North Bay sill resulting in the Chicago-Port Huron two-outlet phase. Researchers, notably Hough (1958, 1963), evolved scenarios where all this could have occurred even given differing rates of uplift. My rendition of the Nipissing phase deviates from the portrayal in the literature (see Noble, 2003a).

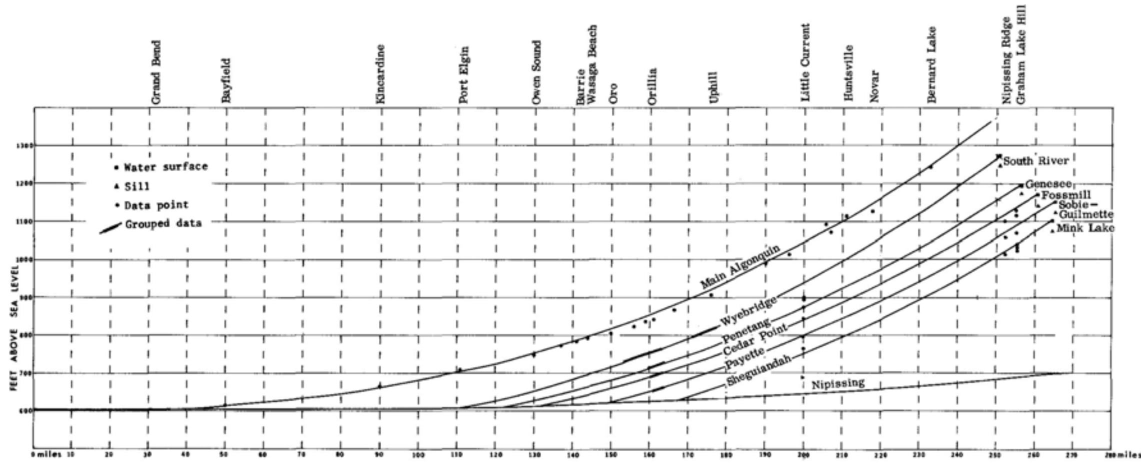

Figure 4. Harrison's (1972) curved profiles and associated outlets for the Algonquin and Post-Algonquin Lakes.

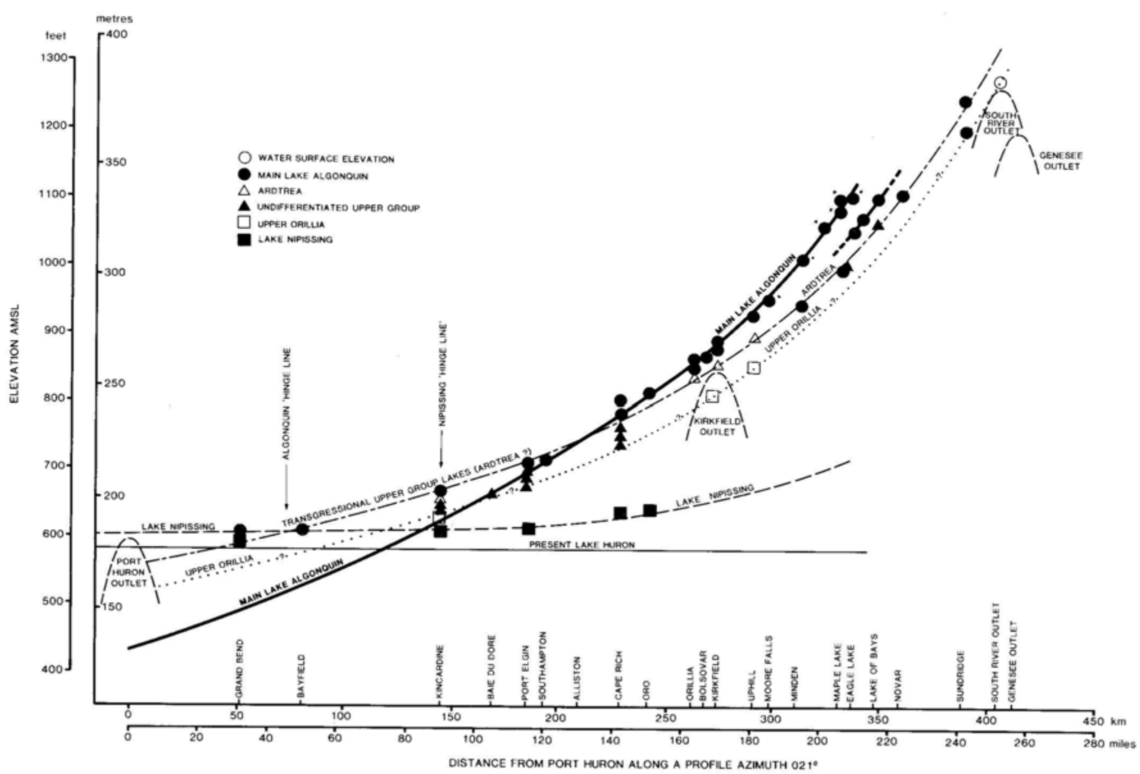

Figure 5. Water plane curves for Main Algonquin and Post-Algonquin Upper Group Lakes in the Huron basin as depicted by Kaszycki (1985).

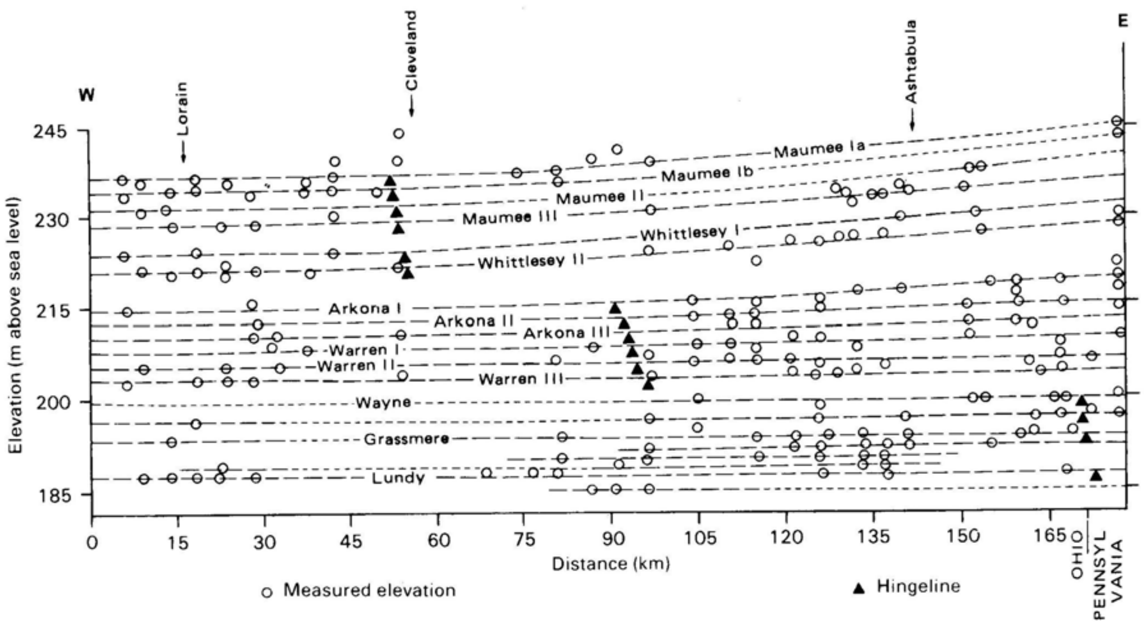

Figure 6. Shoreline profiles on Lake Erie's south shore (the northeastern Ohio portion) according to Totten (1985).

The Chicago outlet is higher and further south than the Port Huron sill. I deviate from the literature's portrayal in that I believe the Chicago outlet only operates when the confluent Lakes Huron and Michigan separate at the Straits of Mackinac. This occurs whenever the North American half of the Northern Hemisphere rotates to the south (i.e., submerges into the Gulf of Mexico) due to an axial shift in that direction (the other half of the Northern Hemisphere is, of course, shifting to the north). Just prior to 10000 BP water levels in the upper Great Lakes were similar to what they are today (i.e., the Earth's surface in this area slowly tipping southwest towards the orbital plane). By 10000 BP, however, the merged Huron-Michigan lake phase ended when it separated to become two smaller water bodies at the Straits of Mackinac. The residual lake occupying the Michigan basin briefly flowed east over the submerged sill near Mackinaw into a remnant Lake Huron that continued draining through Port Huron. With further rotation, however, the Chicago outlet captured drainage duties allowing the remnant Michigan basin water to flow into the Mississippi River system. When the shift ceased the Michigan basin was occupied by a series of small flowage lakes whose water drained over the Chicago sill to eventually enter the sea at Peoria, Illinois on the Wabash River.

One would think the residual Huron basin water body would continue draining over the Port Huron sill. It did but under odd circumstances. Much as today, water backing up behind the Fort Erie-Niagara Falls sill passed over the Port Huron sill to merge with water trying to drain from the Huron basin to the Erie basin. This relationship is more pronounced today, as the Port Huron sill has been lowered by dredging. For a very brief period around 10000 BP the Fort Erie-Niagara Falls sill and the Mackinac outlets controlled this level simultaneously. As the basins continued rotating southwest, the south slope of the Erie basin was submerging. In doing so, older shorelines etched on the south slope were drowned. Sometime after 10000 BP the earth rotated to where St. Marys, Ohio, on the St. Marys River achieved the same elevation as the Mackinac and Fort Erie-Niagara Falls outlets allowing spillage into the headwaters of the Wabash River (Fig. 7). Initial drainage through St. Mary's etched a shoreline at Fort Wayne that was at roughly the 245 metre (805 feet) elevation. Down-cutting at Fort Wayne dropped the water level 1.5 metres (5 feet) and allowed Fort Wayne to capture drainage duties. Although the reduction in water level was small, catastrophic amounts of water flushed down the Little River into the Wabash River to enter the sea at Clinton, Indiana.

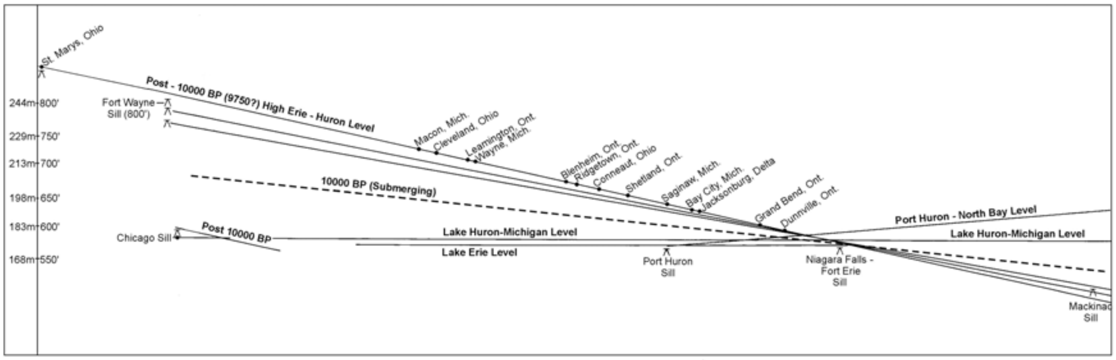

Figure 7. The profiles reflect the submergence of the south side of the Erie basin and the ultimate attainment of this paper's postulated high level Erie-Huron phase. The levels between the two events are later lower phases. The last water body to truncate the high level phase in the Huron portion of the basin was the Port Huron-North Bay level thousands of years later.

The shoreline representing the highest Erie-Huron level now tilts downwards to the north to just beyond Grand Bend, Ontario, in the Lake Huron basin, where it truncates older levels that tilt upwards to the north. These truncated levels are remnants of some of the same drowned levels on the Erie basin's south slope or the basin floor itself. The high level phase disappears just north of Grand Bend due to its later truncation in this area by the Port Huron-North Bay level. Where the two opposing shoreline tilts intersect, marks the closest, elevation-wise, that any older pre–10000 BP emergent level gets to the modern Lake Huron level.

On the Ontario Peninsula the high level Erie-Huron lake-phase is traceable to within Chapman and Putnam's (1966) Bothwell Sand Plain. They characterize this sand plain as a delta that formed where a former version of the Thames River entered glacial Lake Warren. I maintain that this sand plain was constructed by separate events thousands of years apart. The southwestern third of the plain (the youngest part) was scoured by the rising waters of this paper's Erie-Huron phase (Fig. 8). On reaching its ultimate height in this area it formed a shoreline that can be followed from near Bothwell northwest to Shetland. It also bisects the sand plain longitudinally in that it extended up the incised Thames River valley to just beyond Gentleman Creek where it truncates an older profile tilting upward to the north. An excellent example of the lake level is located in the Lake Huron hinterland east of Pinery Provincial Park, where it occurs at the 185-166 metre (605-610 feet) level (Fig. 9). Cooper (1979) refers to this shoreline, now cut by the Ausable River and Parkhill Creek, as the Lakes Nipissing-Algonquin shore-bluff. He states that "it is not possible to separate the two beaches until one moves north of the isostatic hinge line." In my view this bluff is not related to either of those levels but to the high level Erie-Huron level described here. The sharp bluff gives the impression that the high level Erie-Huron phase re-occupied the profile of a much older level when, in fact, it truncates this older level within the perched "Thedford Embayment". It also truncated other older levels further north but evidence of these truncations was obliterated when the above-mentioned Port Huron-North Bay level cut the Erie-Huron shoreline north of Grand Bend.

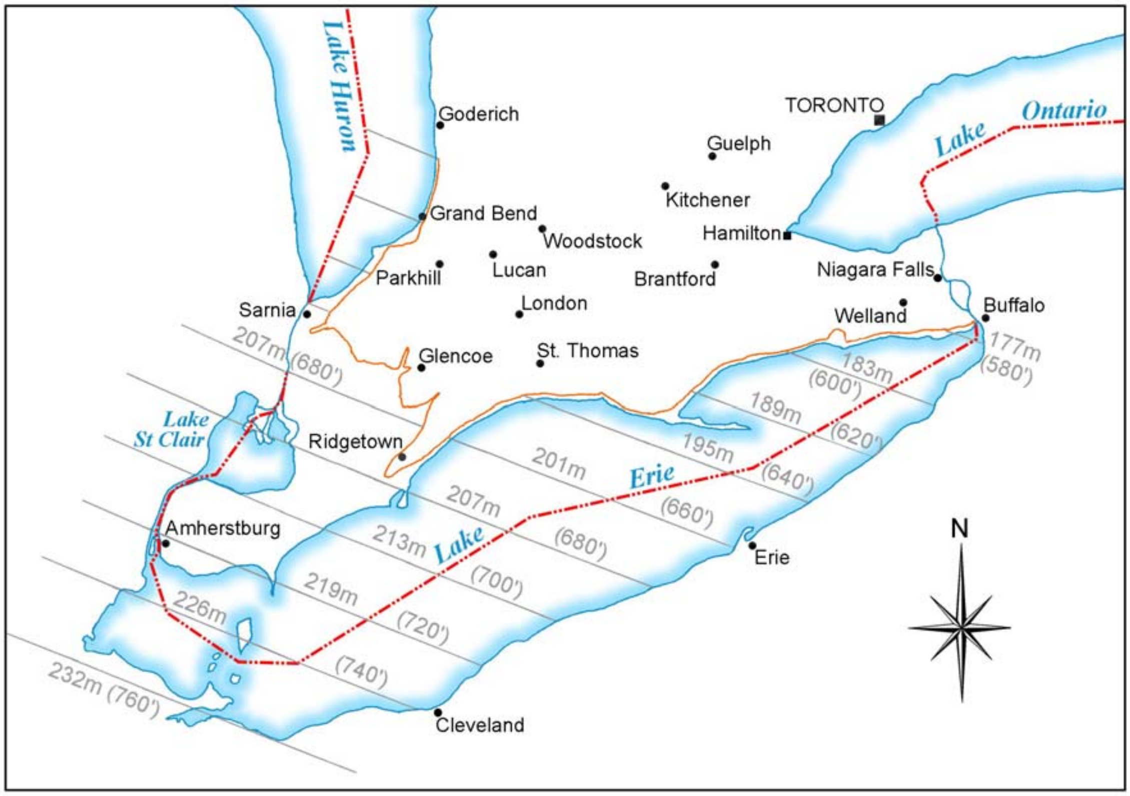

Figure 8. The 'Ontario Peninsula' portion of the High Level Erie-Huron Phase postulated in this paper to have existed shortly after 10000 BP.

Figure 9. The High Level Erie-Huron shoreline in the 'Thedford Embayment' (NTS Map 40P/5).

In the axial shift scenario, this older shoreline, truncated by the Erie-Huron level, was one of a series of shorelines that step down in a tilted ‘wedding cake’ fashion from the top of “Dundalk Island” (this stepping-down process also formed the so-called “Oak Ridges Moraine”). The older southward tilting levels, truncated by the Erie-Huron level in the vicinity of Grand Bend, intersect the Huron basin floor below the Port Huron sill. These older higher levels occupied both basins and are, accordingly, traceable on the other side of the sill sequentially stepping eastward along the now submerged length of the Erie basin floor and on the emergent eastern flank of Dundalk Island. The same chronological events (e.g., the older shoreline truncated by the Erie-Huron level) that occurred in the Huron basin’s Thedford Embayment are replicated in the Port Dover area in today’s Erie basin (e.g., the older truncated level emerges from under Lake Erie near Port Dover). Later truncations of the Erie-Huron level in the Lake Huron basin did not happen in the Lake Erie basin. The seawater of the 7800 BP Nipissing Transgression, that passed over the North Bay and Kingston sills, did not reach the Erie basin, which was occupied at the time by a steep gradient river connecting a series of small flowage lakes. The Nipissing Transgression did, however, get as far west in the Lake Ontario basin as Goat Island above the lip of today’s Niagara Falls. That portion of the high level Erie-Huron shoreline in the Lake Huron basin was truncated last by the above-mentioned Port Huron-North Bay level, which was a freshwater lake confined to that basin by the respective Port Huron and North Bay sills. The Erie basin held three small flowage lakes at that time.

THE FORT WAYNE CONUNDRUM

As with the Chicago outlet, there is much confusion regarding outflow at Fort Wayne. Calkin and Feenstra (1985), using an ice-margin recession scenario, describe the highest Lake Maumee phase (Maumee I) as stabilizing at 244 metres (800 feet) at about 14500 BP. They indicate that two subsequent phases are distinguishable, namely Middle Maumee (Maumee III) at 238 metres (780 feet) and Lowest Maumee (Maumee II) at 232 metres (760 feet). Leverett and Taylor (1915) indicate that the Lowest Maumee preceded and was submerged by Middle Maumee. Calkin and Feenstra indicate, however, that the Lowest Maumee level was either reoccupied after the Middle phase or was possibly third rather than second in the sequence. There are features in the Fort Wayne area that relate to about 14500 BP but I believe the opening of the Fort Wayne outlet took place shortly after 10000 BP without the involvement of glaciers. The confusing Fort Wayne scenario relates to the drowning of older profiles on the Erie basin’s south slope in response to not one but a number of axial shifts. One might conclude that the initial down-cutting phase at Fort Wayne, in turn, led to two sequential phases whose stabilized profiles would have been parallel to one another. I don’t think this was the case.

The key to understanding the Fort Wayne chronology centres on the western end of Lake Superior within Jay Cooke State Park on the St. Louis River upstream from where it enters the harbour at Duluth, Minnesota (Noble, 2003c). The older and higher shoreline profiles in the Duluth embayment tilt up towards the north. The ones below the 237 metre (775-780 feet) contour, however, tilt down towards the north. None of the latter profiles reach the Canada-United States boundary due to their having been truncated by later water levels that primarily occupied the north side of the basin. The upper three of the lower profile sequence replicate the chronology of events that constructed the three outflow levels at Fort Wayne. The elevations are rough estimates but the highest level at Jay Cook State Park (236-237 metres; 775 feet) corresponds with the abrupt draw-down phase at Fort Wayne where water levels dropped 1.5 metres (5 feet) to stabilize at the 244 metre (800 feet) level (Fig.10). That event established Fort Wayne as an outlet and the abandonment of the Niagara Falls and Mackinaw outlets.

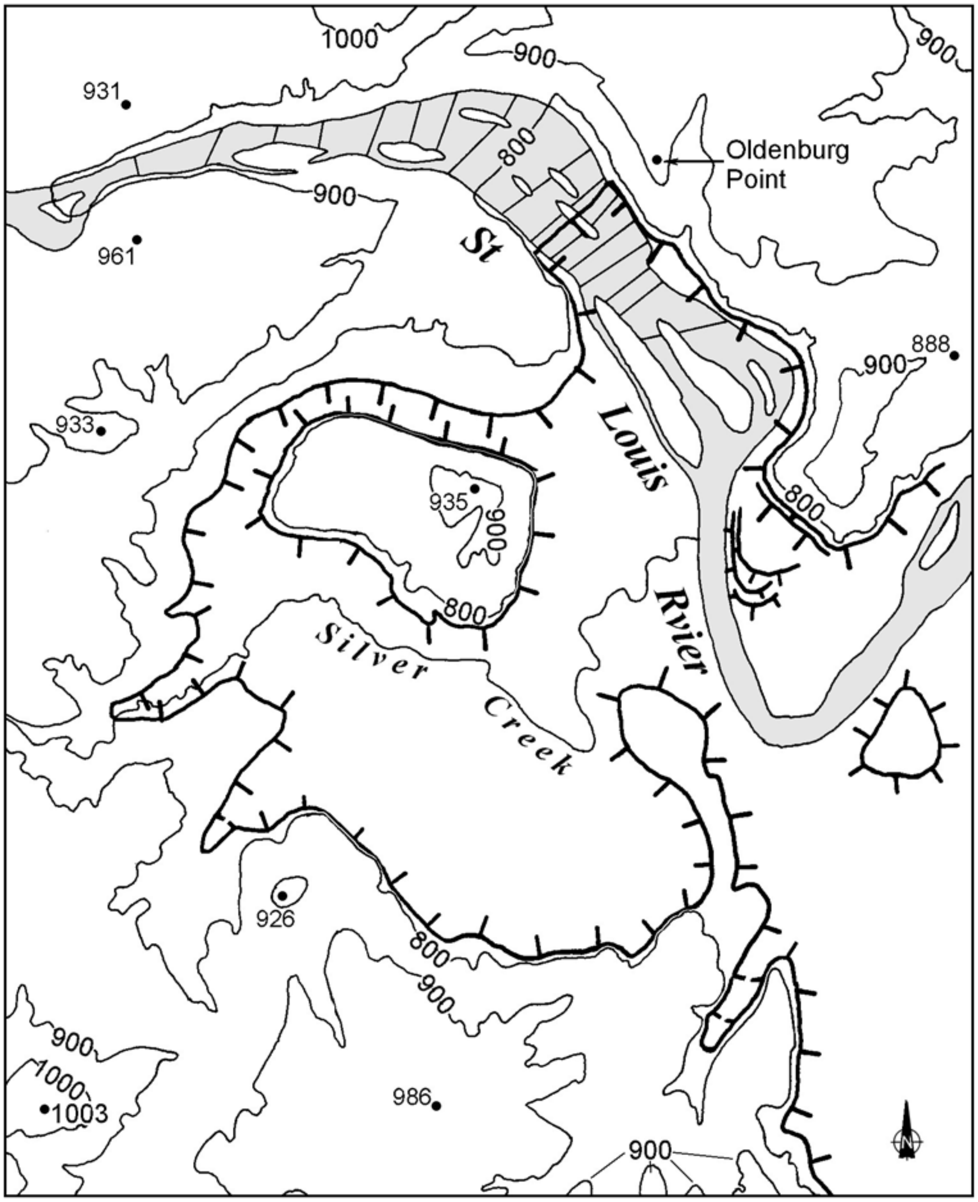

Figure 10. The sequence of Proto-Superior shorelines (Noble, 2003c) below the 800 foot contour in Jay Cooke State Park on the St. Louis River southwest of Duluth, Minnesota, may mirror the events and shoreline sequence postulated in this paper to have occurred in the Maumee River valley at Fort Wayne, Indiana.

The next step is important because the affiliated events were repeated numerous times. The axis shift back caused the basins to tip northeast, which led to the abandonment of the high level Fort Wayne outlet; the re-establishment of the Niagara River outflow and the re-opening of the falls; and the draining of the Erie basin. It ultimately led to the isolation of the Port Huron sill but not before water backed up behind both it and the Chicago sill allowing the water in the

Michigan and Huron basins to again merge. As the shift continued the Chicago outlet was abandoned, leading to the creation of what would be one of a series of Port Huron-North Bay levels. Ultimately, North Bay would be the only operating outlet draining small flowage lakes from the upstream basins. When the shift stopped, seawater submerged low saddles along what is now the watershed divide separating the Great Lakes and Arctic watersheds as well as the Ottawa River and the North Bay sill. Masses of floating sea ice (e.g., large ice islands, icebergs, etc.) in the then Hudson Bay, impacted the back slope of the present watershed divide where they formed ice ramparts that mark grounding lines. The low saddles acted as choke-points for these ice masses. In Ontario, the highest or shallowest such saddle was near Mojikit Lake north of Lake Nipigon. The so-called Crescent Moraine and/or the sequence of Nakina Moraines, may relate to this event. The interaction between a moving earth, seawater, floating ice and tides formed or reshaped previously formed drumlin fields in front of the grounding lines. The widest and deepest of these gaps was centred on the Rouyn-Noranda area in the Province of Quebec. This sea level (Korah) occupied the Superior, Huron and Ontario basins. The Erie and Michigan basins were essentially empty being occupied by flowage lakes and rivers that drained to their respective Korah seawater embayments in the Huron and Ontario basins.

The entire process reversed in the next shift back to the southwest but the amplitude of the shift was less. This reflects a cycle within a cycle periodicity. The previous cycle had marked the termination of a large cycle that put places such as Fort Wayne, Duluth and Lake Traverse further south than they had been for more than 10000 years and maybe even 20000 years. Those places experienced their highest amounts of insolation at this time, while on the other side of the hemisphere the Caspian Sea area was experiencing cooler and moister conditions. The second shift in the sequence, in coming up short (i.e., the new Erie-Huron level drained over a sill at Fort Wayne at roughly the 238 metre (780 foot) level), marked a new large cycle trend in the Northern Hemisphere, namely, a long term movement back to the north. Water again drained down the Little River system to join the Wabash River but this time reached the sea some distance downstream from Clinton, Indiana. Its sister level in the southwest end of the Superior basin in Jay Cooke State Park is located at roughly the 227-228 metre (745-750 feet) level. The respective level in the Lake Winnipeg basin drained over the Lake Traverse-Mud Lake sill but its profile would disappear in the shift back to the north.

The entire sequence of events was repeated in the next cycle, which ultimately established an outlet in Fort Wayne at the 232 metre (760 feet) level. The sister level at Jay Cooke State Park in the Superior basin was at roughly the 223-224 metre (730-735 feet) level. Subsequent cycles stopped below the Fort Wayne sill (i.e., further down the Maumee River valley). Figure 11 below summarizes how the one shift produced the corresponding levels in each of the respective basins mentioned here, namely, the Lake Winnipeg basin (i.e., the Red River valley), the Upper Great Lakes Superior basin and the Erie basin of the Lower Great Lakes. Lake Huron, tucked between the Lake Superior and Lake Erie levels, is not shown in Figure 11 for scale reasons. However, when the profiles in this figure are viewed in conjunction with Figures 7 and 8, one must surmise that the distinction between the Upper and Lower Great Lakes is an ephemeral one. Variations on today's Huron-Michigan phase and the postulated Erie-Huron phase have been with us before. I infer from this that the present Huron-Michigan phase is slowly evolving to become this paper's Erie-Huron phase or a rough facsimile of it at some future date.

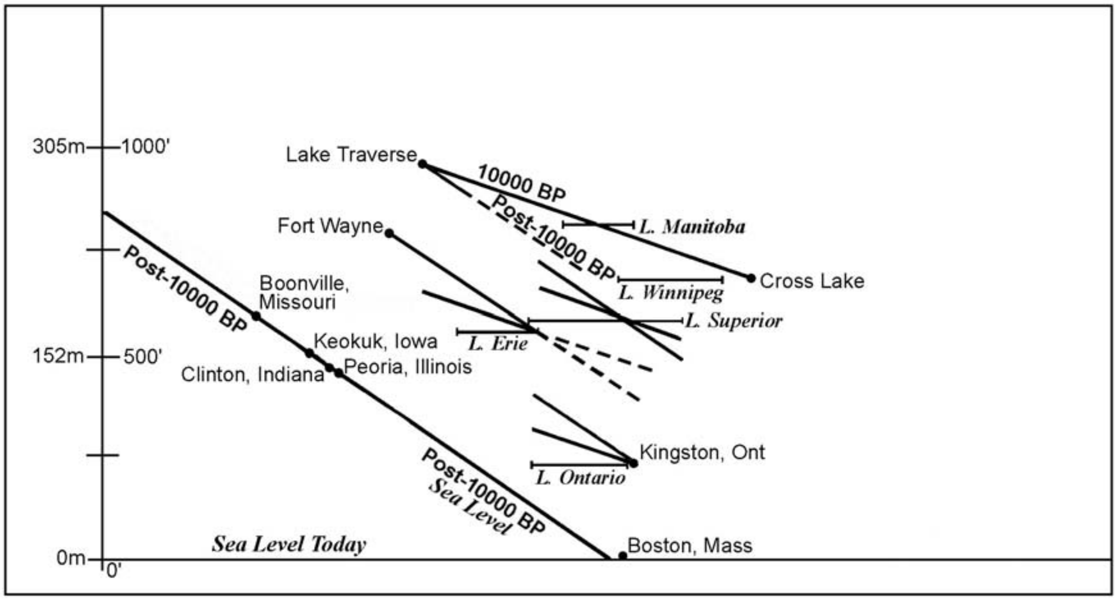

Figure 11. Shoreline profiles that evolved in the respective basins described in the paper circa 10000 BP (the present Huron-Michigan level between the Lakes Superior and Erie levels is not shown for scale reasons).

CONCLUSIONS

The axial shift concept presented here contradicts the events and processes typically used to characterize basin development in the Northern Hemisphere generally and the Lakes Erie, Huron and Michigan basins specifically. The existence of shoreline profiles with opposing tilts negates isostatic rebound, curved shoreline profiles and, in part, continental glaciation.

In the Nipissing paper (Noble, 2003a) I pondered the origins of axial shifts. Were they a response to water and ice sloshing around the world creating an imbalance? Failing this, were shifts a response to an external celestial stimulus? Examples of the latter might involve a comet; asteroids; or planet positions related to the plane deviation and eccentricity of Pluto and its moon's orbit. Perhaps the periodic shift is evidence of a planet beyond Pluto with a long cycle that interacts with the Earth's orbit. Whichever, opposing shoreline profiles portray a cyclic pattern having a rough regularity; abrupt directional changes at some stage or stages; and a smaller cycle pattern within a larger one. The cycles may fall within the realm of Milankovitch's (1941) cycles (i.e., orbital eccentricity, axial tilt, wobble), however, the net affect of his axis variation is supposedly only 1.5 degrees either side of the Earth's purported relatively constant 23.5 degree tilt. Does the 10000 BP event and its respective shoreline profile mark the termination of a large cycle that relates to Milankovitch's axial tilt (i.e., obliquity) that followed a path lasting thousands of years? Do the intervening opposing profiles mark smaller swings back and forth along the axial shift path in the manner of a vibrating tuning fork or wobble of the polar axis? The opposing tilts and the amplitude of their angles suggest that larger axial shifts do occur, or, minimally, large changes in the hypothesized disconnect between the Earth's mass and its water bodies occur in response to the presently accepted minor shift amplitude of three degrees.

Time will tell if the presented profiles owe their origins to a periodic celestial event. Might there be some basis, however, for water moving around the world, possibly, even self-induced, if one assumes a disconnection between the Earth's surface and its water? This scenario is not unlike the novelty store bird that tips its beak into a water-filled glass. Is Milankovitch's tilt or, minimally, polar wobble, in conjunction with the large freshwater lakes and inland seas in the mid-latitudes, enough to cause the equatorial axis to over-rotate and to instigate an alternating freshwater-seawater cycle for lakes at the lower elevations? The weight of the water in these basins is infinitesimal in relation to the Earth's total mass. However, is the Earth's incline so finely balanced that the weight of the water swashing back and forth in the vicinity of continental divides can throw it out of balance? For example, proto-Lake Winnipeg at its greatest extent stretched a distance of almost 1000 kilometres (600 miles) from Cross Lake to the Continental Divide. That is a large water body by any standard.

The Lake Traverse-Mud Lake sill is the furthest south that the Arctic watershed reaches in North America. Did water backing up over such a long distance behind the Cross Lake sill trigger an over-rotation? At some point, did the water in the Red River valley, and other basins close to the Mississippi River watershed (i.e. the Erie-Huron lake phase described here), act like a moving weight along a teeter-totter to produce an over-rotation? Did the passage of water beyond a fulcrum point accelerate the shift permitting the capture of the Lake Winnipeg watershed and the then upper Great Lakes watershed (Lake Ontario still drained down the St. Lawrence system) by the Mississippi River system? Given the land-water disconnect, this led to the submergence of the Mississippi River valley and the emergence of the Hudson Bay floor. The net effect was the inundation of the Mississippi River valley and its tributaries by seawater. Consequently, large amounts of water from the first proto-Lake Winnipeg level in the Red River valley met the sea at Boonville on the Missouri River. Simultaneously, the small flowage lake in the Michigan basin drained over the Chicago sill to meet the sea at Peoria, Illinois, on the Wabash River and the highest Erie-Huron level with tributary overflow from the Superior basin met the sea at Clinton on the Wabash River. At this time seawater was as far up the main channel of the Mississippi as Keokuk, Iowa.

The foregoing may account for the over-rotation but, more importantly, did the release of this water (e.g., the 1.5 metres (5 feet) of water depth) from what was then the upper Great Lakes and from proto-Lake Winnipeg) cause the equatorial axis to snap back rapidly in the opposite direction? Did the Arctic Slope then abruptly submerge again under seawater and, conversely, the Mississippi River valley to emerge from it? Was the build up of sea ice so massive along the perimeter of the reconfigured Arctic water body that enormous ice ramparts formed to mark the termination of this shift in the opposite direction? Was the shift back from the 9700-10000 BP position the beginning of the end for mastodons and other large mammals? Do refuges with high species diversities and large numbers of endemic species (e.g., Appalachian Mountains, Lake Baikal) owe their existence to the fact that their high elevations have been isolated much longer from the destructiveness of these shifts? Could one rain-storm in the Red River valley been the straw that broke the camel's back? The self-induced scenario of water sloshing around the hemisphere, or even an unbalanced ice buildup at the poles, has a 'perpetual motion machine' ring to it. One must then conclude that an external celestial stimulus induces the gyroscopic disconnection between the earth's landmass and its water and that the opposing tilts of the shoreline profiles postulated in this paper are evidence of this repetitive event.

ACKNOWLEDGEMENTS

I gratefully acknowledge Cathy Chapin for discussion and preparation of the figures.

REFERENCES

Calkin, P.E. and Feenstra, B.H., 1985. Late Wisconsinan and Holocene History of the Lake Superior Basin, in Karrow, P.F. and Calkin, P.E., eds., Quaternary Evolution of the Great Lakes: Geological Association of Canada, Special Paper 30, p. 149-170.

Chapman, L.J., and Putnam, D.F., 1966. The Physiography of Southern Ontario: University of Toronto Press, 2n ed., 386 p.

Cooper, A.J., 1979. Quaternary Geology of the Grand Bend Area, Southern Ontario: Ontario Geological Survey Report 188, 70 p.

Dawson, G.M., 1875. Report on the Geology and Resources of the Region in the Vicinity of the Forty-ninth Parallel, from the Lake of the Woods to the Rocky Mountains with Lists of Plants and Animals Collected and Notes on the Fossils: North American Boundary Commission, 1872-1875.

Farrand, W.R. and Drexler, C.W., 1985. Late Wisconsinan and Holocene History of the Lake Superior Basin, in Karrow, P.F. and Calkin, P.E., eds., Quaternary Evolution of the Great Lakes: Geological Association of Canada, Special Paper 30, p. 17-32.

Harrison, J.E., 1972. Quaternary Geology of the North Bay-Mattawa Region: Geological Survey of Canada Paper 71-26, 109 p.

Hough, J.L., 1958. Geology of the Great Lakes: University of Illinois Press, Urbana, Illinois, 313 p.

Hough, J.L., 1963. The Prehistoric Great Lakes of North America: American Scientist, vol. 51, no. 1, p. 84-109.

Hughes, J.D. and Merry, W.J., 1978. Marquette Buried Forest 9850 years Old: Abstract for the American Association for the Advancement of Science Annual Meeting, February 12-17.

Kaszycki, C.A., 1985. History of Glacial Lake Algonquin in the Haliburton Region, South Central Ontario, in Karrow, P.F. and Calkin, P.E., eds., Quaternary Evolution of the Great Lakes: Geological Association of Canada, Special Paper 30, p. 109-123.

Lawson, A.C., 1893. Sketch of the Coastal Topography of the North Side of Lake Superior with Special Reference to the Abandoned Strands of Lake Warren: Geology and Natural History Survey of Minnesota, 20th Annual Report, 1891, p. 181-289.

Leverett, F. and Taylor, F.B., 1915. The Pleistocene of Indiana and Michigan and the History of the Great Lakes: United States Geological Survey Monograph 53.

Milankovitch, M., 1941. Kanon der Erdbestrahlungen und seine Anwendung auf das Eiszeitenproblem: Belgrade.

Noble, T.W., 2003a. A Re-interpretation of World Sea Levels: the Nipissing Transgression: www.axialshift.com.

Noble, T.W., 2003b. A Re-interpretation of World Sea Levels: the Agassiz Problem: www.axialshift.com.

Noble, T.W., 2003c. A Reinterpretation of World Sea Levels: the Marquette Problem: www.axialshift.com.

Teller, J.T. and Thorleifson, L.H., 1983. The Lake Agassiz - Lake Superior Connection, in Teller, J.T. and Clayton, L., eds., Glacial Lake Agassiz: Geological Association of Canada, Special Paper 26, p. 261-290.

Totten, S.M., 1985. Chronology and Nature of the Pleistocene Beaches and Wave-cut Bluffs and Terraces, Northeastern Ohio, in Karrow, P.F. and Calkin, P.E., eds., Quaternary Evolution of the Great Lakes: Geological Association of Canada, Special Paper 30, p. 171-184.

Upham, W., 1880. Preliminary Report on the Geology of Central and Western Minnesota: Minnesota Geological and Natural History Survey 8th Annual Report (1879), p. 70-125.

Upham, W., 1890. Report on Exploration of the Glacial Lake Agassiz in Manitoba: Geological Survey of Canada Annual Report for 1888-1889, v. 4, section E, 156 p.