Evidence strongly suggests the Laurentide Ice Sheet was thin

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The Ice Age has many unknowns for uniformitarian science. One of those is the thickness of former ice sheets. Several methods are used to estimate their thickness, one of which is to simply claim by analogy that the thickness of former ice sheets was similar to the Antarctic Ice Sheet. A second method is to estimate sea level fall during the Ice Age and translate that into ice sheet volume. However, estimates of sea level fall assume a large ice volume, which is circular reasoning. Instead of uncertain analogies and indirect estimation, a more empirical thickness can be deduced from the multidomed nature of the Laurentide Ice Sheet, its unglaciated margins, and observations of glacial rebound. Such an analysis reveals that the Laurentide Ice Sheet, as well as the Cordilleran and Scandinavian Ice Sheets, were much thinner than previously believed. This also means that the maximum sea level reduction during the Ice Age was correspondingly less.

Uniformitarian scientists have difficulty explaining the Pleistocene Ice Age.[1] One major problem is determining how an ice age could begin. They know that the geological evidence requires some sort of ice age explanation. Secular scientists have devised dozens of hypotheses to explain how ice ages could have occurred, the most popular of which is currently the Milankovitch (or astronomical) theory. The Milankovitch theory posits that ice ages are 'paced' by slow, gradual changes in Earth's orbital motions over many hundreds of thousands of years. These changes modulate the amount of summer sunlight in the northern high latitudes, ultimately causing the ice sheets to retreat or advance. But even this popular theory has numerous problems, the most obvious of which is the difficulty of ice ages being caused by such small changes in the distribution of solar insolation when integrated for warm and cold half years and whole hemispheres.[2] Of course, they do not consider that the problem is the uniformitarian assumption itself.

It is universally agreed the ice sheets built up with time, reached a maximum thickness, and later melted during deglaciation. Unfortunately, many details about these former ice sheets have been lost, such as their precise areas and thicknesses.

According to the uniformitarian model, ice ages properly began with the development of the Antarctic Ice Sheet about 34 Ma ago, if not before, reaching its present thickness about 15 Ma ago.[3] Uniformitarians also believe the Greenland Ice Sheet started developing around 38 Ma ago and reached steady state about 2.7 Ma ago.[4] Then about 2.6 Ma ago, the start of the Quaternary period, they believe that the ice sheets that no longer exist started a glacial/interglacial cycle that repeated every 40,000 years until about a million years ago, at which time the period mysteriously changed to 100,000 years.[5–7] Uniformitarians now believe that the total number of ice ages of various intensities in the Quaternary was over 50.[8] Since each ice age is thought to erase practically all geological evidence for former ice ages, uniformitarian scientists have determined the number of ice ages from chemical 'wiggles' in the deep sea cores, interpreting those 'wiggles' under the assumption that the Milankovitch theory of Pleistocene ice ages is true. These 'wiggles' are then used to calibrate age-depth models, which assign ages to the deep ice cores, particularly those of central Antarctica. However, they then claim that deep sea cores, as well as ice cores, support the astronomical theory of ice ages—a process steeped in circular reasoning.[9]

In the creation model, there were no ice sheets immediately after the Flood, so the Greenland and Antarctic Ice Sheets developed during the single post-Flood Ice Age, rapidly at first and afterwards continuing to build slowly until reaching a steady state.[10] Immediately after the Flood, sea level was about 68 m higher than today because there were no ice sheets.[11] Absence of the Antarctic would add an equivalent of 61 m of sea level rise,[12] while Greenland would add 7 m.[13] At the peak of the Ice Age, sea level is estimated to have fallen about 55 m below that of today, assuming the ice sheets were about half the size of uniformitarian estimates.[14]

How thick were the former ice sheets?

The greatest difficulty for both models is estimating the thicknesses of the former ice sheets, since they no longer exist. Uniformitarian scientists commonly rely on theoretical concepts within their model:

> "Because the ice sheets left little direct evidence of their height, estimates of LGM [Last Glacial Maximum] ice volume have come largely from indirect evidence or from glaciological modelling."[15]

Thicknesses based on current ice sheets

The Laurentide Ice Sheet existed over central and eastern Canada and the adjacent northern United States during the Ice Age and was the largest former ice sheet (figure 1). Estimating its volume can provide an approximate total ice volume for the Ice Age by assuming the Scandinavian and Cordilleran Ice Sheets were the same thickness. The Scandinavian Ice Sheet developed over northern Europe and northwest Asia, while the Cordilleran Ice Sheet covered the mountainous areas of British Columbia, Canada, and the adjacent northern United States.

The main assumption uniformitarian scientists have used to explain ice sheet thicknesses is time. Since they allow for hundreds of thousands to millions of years for ice sheets to develop, they commonly assume that the former ice sheets built up to the thicknesses of the present ice on Antarctica or Greenland. With reference to the Laurentide Ice Sheet during the Ice Age, Bloom states:

> "Unfortunately, few facts about its thickness are known. … In the absence of direct measurements about the thickness of the Laurentide ice sheet, we must turn to analogy and theory."[16]

Andrews added:

> "There have been several reconstructions of various Pleistocene ice sheets based essentially on glaciological theory. These have relied implicitly or explicitly on the analog premise that the appearance of the former ice sheets was not unlike that of the Greenland or Antarctic ice sheets today. This premise may not be valid."[17]

And Bonelli *et al.* admit to major uncertainties: "However, uncertainties still remain about the shape, volume and thickness of these former ice sheets."[18]

Despite its lack of empirical validity, Christoffersen *et al.* recently reinforced the belief that, like Antarctica, the Laurentide Ice Sheet was up to 4 km thick: "Comparable hydrologic systems may have existed beneath the Laurentide Ice Sheet, which was similar in size to the modern Antarctic Ice Sheet."[19] This ice thickness is assumed in numerous computer climate simulations, including in the Ice-4G model.[20] The Ice-4G model is the fourth in a series of ice-thickness models that are used as input to numerical simulations.

There is another reason why uniformitarian scientists believe the Laurentide Ice Sheet built up to 4 km thick. They believe the ice sheet started in northern Canada (Hudson Bay area) and slowly crept into the northern United States over tens of thousands of years. So for the Laurentide Ice Sheet to move from near sea level in central Canada to northern Montana, it would have to push uphill about 1,000 metres. How could this happen? On level ground, the driving force for ice movement is the surface slope of the ice itself, *not* the (small) slope of the ground:

> "The driving stress, and hence the shear stress at the bed, are determined by the surface slope. Ice therefore tends to flow in the direction of maximum surface slope even if the bed slopes in the opposite direction."[21]

So the Laurentide Ice Sheet could indeed flow uphill if the central part of the ice sheet were thick enough to ensure that the surface slope of the ice still dipped downward to the south. A 4 km thick ice sheet is thought to be able to accomplish this, if indeed this is what happened.

Thicknesses based on sea level fall

A second method commonly used to estimate the thicknesses and volumes of the former ice sheets is to determine the amount of sea level fall believed to have occurred at the last glacial maximum.[22] However, past sea levels are unknown since there are several variables which determine sea level at any one place. Tarasov and Peltier admit:

> "Past reconstructions of the deglaciation history of the North American (NA) ice-sheet complex have relied either on largely unconstrained and limited explorations of the phase space of solutions produced by glaciological models *or upon geophysical inversions of relative sea-level (RSL) data* which suffer from incomplete geographic coverage of the glaciated regions, load history amplitude/timing ambiguities, and lack of a priori glaciological self-consistence [emphasis added]".[23]

A 2002 article in *Quaternary Science Reviews* was titled: "Estimating past continental ice volume from sea-level data",[24] showing that one method of estimating ice sheet height is by taking the lowest postulated ice age sea level and projecting the missing ocean water onto the land as ice.

How is the lowest sea level determined? It is common practice for uniformitarian scientists to estimate past sea levels *based* on presumed ice sheet thickness and volume. So they calculate sea level had fallen to around 110–120 m below that of today for an Antarctic-like ice sheet over North America and Eurasia. Flint candidly admitted:

> "A greater potential error [in estimating sea level] lies in the estimation of average thickness and volumes of glaciers, particularly ice sheets that no longer exist. Thus far the profiles of such glaciers have been *reconstructed by analogy with those of existing ice sheets,* which for one reason or another may not be truly analogous [emphasis added]."[25]

Since they 'know' how far the sea level fell during the last glacial maximum, they search for sea level indicators at about 110–120 m depth. They assume the edges of stable continental shelves did not uplift or sink during the Ice Age or afterwards. Since sea bottom features can be formed in various ways, unrelated features could be claimed as evidence of the expected former sea level. This is another example of the reinforcement syndrome that is so pervasive in uniformitarian earth science.[26,27]

Ice sheets not that thick?

Laurentide Ice Sheet multi-domed

Whereas earlier models assumed that there was one single-domed, thick Laurentide Ice Sheet centred over Hudson Bay, other evidence indicates the ice sheet was multi-domed and thinner. There are many pieces of evidence, which include: the direction of striated bedrock; the long axes of drumlins, grooves, and roches moutonnées; and the provenance of erratic boulders.[28,29] Drumlins are streamline-shaped hills of glacial till elongated in the direction of ice movement. Long glacial grooves form by rocks embedded in the bottom of a glacier carving into bedrock that can stretch for kilometres. Roches moutonnées are small streamlined bedrock hills, and erratic boulders are large till material that do not have a local source but have been transported from another area. This evidence demonstrates there were at least two major domes on the Laurentide Ice Sheet, one west and northwest of Hudson Bay in Keewatin and the other east of Hudson Bay over Labrador, because the orientated features point away and erratics spread from these centres. Other possible ice domes are over Baffin Bay/Foxe Basin, the Queen Elizabeth Islands, and between Hudson Bay and the Great Lakes (figure 1).

Some glaciologists have attempted to dismiss the multiple domes as a result of late glacial thinning from a single dome that melted down and broke up into multiple domes.[30] However, the presence of erratic boulders and cross-cutting glacial lineations provides evidence against the break-up of a single dome. Distinctive glacial erratics on and below the surface show the Keewatin ice dome during the Ice Age was always in the same location and that ice *never* flowed westward over the area from a large ice dome in Hudson Bay.[31] In addition, evidence indicates that the ice-flow direction on the east side of Hudson Bay was always toward the west, presumably from a separate ice dome on Labrador.[32,33] This is because the ice flow indicators and erratics diverge from both Keewatin and Labrador ice domes. As such, the multidome Laurentide Ice Sheet is now mostly accepted by mainstream scientists.[34,35] Klemens *et al.* state: "Our results reveal that ice-dispersal centres in Keewatin and Quebec [the Labrador ice dome] were dynamically independent for most of pre-LGM time."[36] A new gravity survey also shows that there were two main ice domes.[37,38]

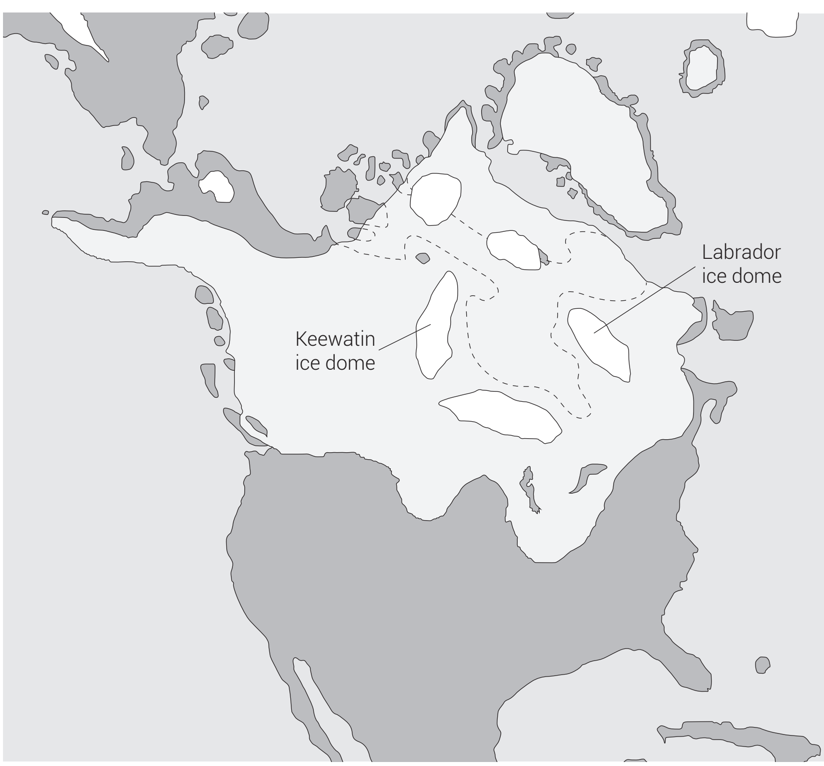

Figure 1. The Cordilleran Ice Sheet, western Canada, and the Laurentide Ice Sheet, central and eastern Canada, showing two major domes west and east of Hudson Bay and three other postulated ice domes over the Laurentide Ice Sheet. (Drawn by Mrs Melanie Richard.)

A multidomed ice sheet implies that the Laurentide Ice Sheet was substantially thinner than today's ice sheets over Antarctica or Greenland.[39] Occhietti concluded: "These results change the concept of the Laurentide ice sheet radically. They imply, notably, a much smaller ice volume, and complex margins."[40]

The Cordilleran Ice Sheet was also likely thin. Ice flow lines in the interior of British Columbia were strongly influenced by the underlying topography, indicating a fairly thin ice sheet that did not overflow the mountainous valleys.[35] Thinner ice sheets are influenced by topographical variations, while thick ice sheets, like observed on Antarctica, often flow across topography.

Ice thin along the margin

Not only does the interior of the Laurentide Ice Sheet indicate a thinner ice sheet, but also the marginal area. Here, ice thicknesses can be deduced by the height of nunataks, which are

Figure 2. Haystack Butte (left) and Middle Butte (right) in the Sweet Grass Hills, north-central Montana, USA, the tops of which stuck up above the ice as nunataks (view west)

mountains or hills that protruded unscathed above the ice, and the height of lateral features, like lateral moraines, left from ice lobes. Ice lobes very likely are the results of glacial surges, which are sudden increases in glacial velocity of about 10 to 100 times that are likely caused by water lubricating the base of the glacier/ice sheet (see below).

Evidence suggests that the southwest edge of the Laurentide Ice Sheet was very thin. This is based on the Cypress Hills and Sweet Grass Hills of north-central Montana (figure 2). The tops of these two hills stuck above the ice, determining the height of the ice sheet at 200 to 300 m thick in this area.[41] Thus, the top of the ice sheet had little southerly slope between the Cypress Hills of southern Canada and the Sweet Grass Hills of north-central Montana.[42,43] Of course, along the edge, the surface slopes to the south, but the slope from the edge to the Cypress

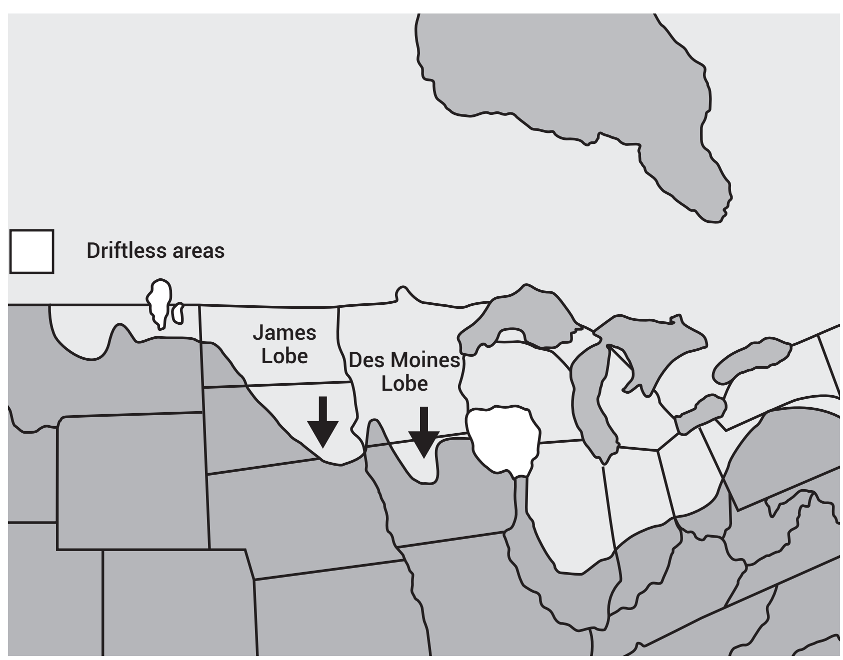

Figure 3. The boundary of the 'last' ice age in the US Midwest, which I believe is the real boundary of the Ice Age. Two driftless areas occur in southwest Wisconsin and northeast Montana and south-central Saskatchewan. Note the James and Des Moines lobes, which probably represent surges. (Drawn by Mrs Melanie Richard.)

Figure 4. Erosional remnants of St Peter Sandstone in the driftless area of southwest Wisconsin

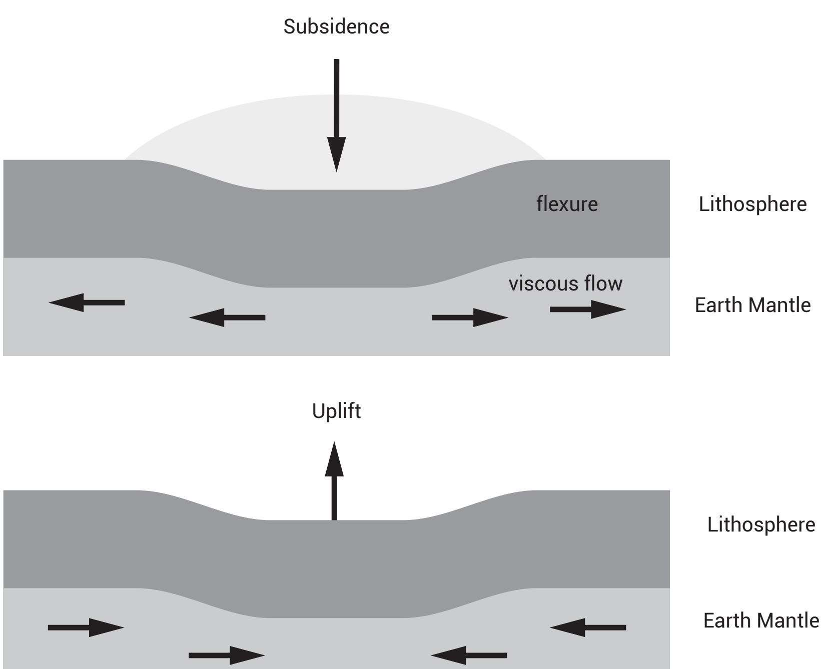

Figure 5. Glacial isostasy. In the top diagram, the ice pushes the lithosphere down but after the ice melts, the lithosphere slowly rebounds upward. (Drawn by Mrs Melanie Richard.)

Hills is about 20% of that along the edge of the Antarctic Ice Sheet.[43] This edge of the ice was either the result of a surge from central Canada southward to northern Montana or else the ice sheet in the area more or less grew in place, or both. Creationists do not have to model a 4-km-thick ice sheet in central Canada to explain the ice sheet in northern Montana since in their model the ice sheets more or less grew in place with instant winter right after the Flood.[1]

In the north-central United States, two lobes are claimed to have developed during the 'last' glaciation (the Wisconsin), which travelled as far as southeast South Dakota (the James Bay lobe) and north-central Iowa (the Des Moines lobe) (figure 3). There do not appear to be any signs of glaciation, such as lateral and end moraines, south of these lobes, except erratic boulders and a covering of glacial debris (personal observations), which could have been deposited by glaciofluvial and glaciolacustrine processes during deglaciation.[44] The James Bay and Des Moines lobes were most likely thin, filling up the low-lying areas of the terrain.[45] Horseshoe-bounding moraines are claimed around the Des Moines lobe that would indicate the lobe was thin and gently sloping.[43,45] This method is based on assuming that the highest moraine elevation in any lateral moraine corresponds to the ice surface elevation at that point and by connecting points on the corresponding lateral moraine. By lining up the elevations within the horseshoe-shaped moraines, it has been deduced that the edge of the lobes was thin. This method has its drawbacks, but most glacial geologists accept that these lobes were thin.[46] The problem with such a thin margin is that the driving stress of the Des Moines lobe, its southerly surface slope, is way too small for it to have slowly spread from the north,[47] unless it surged southward from the north,

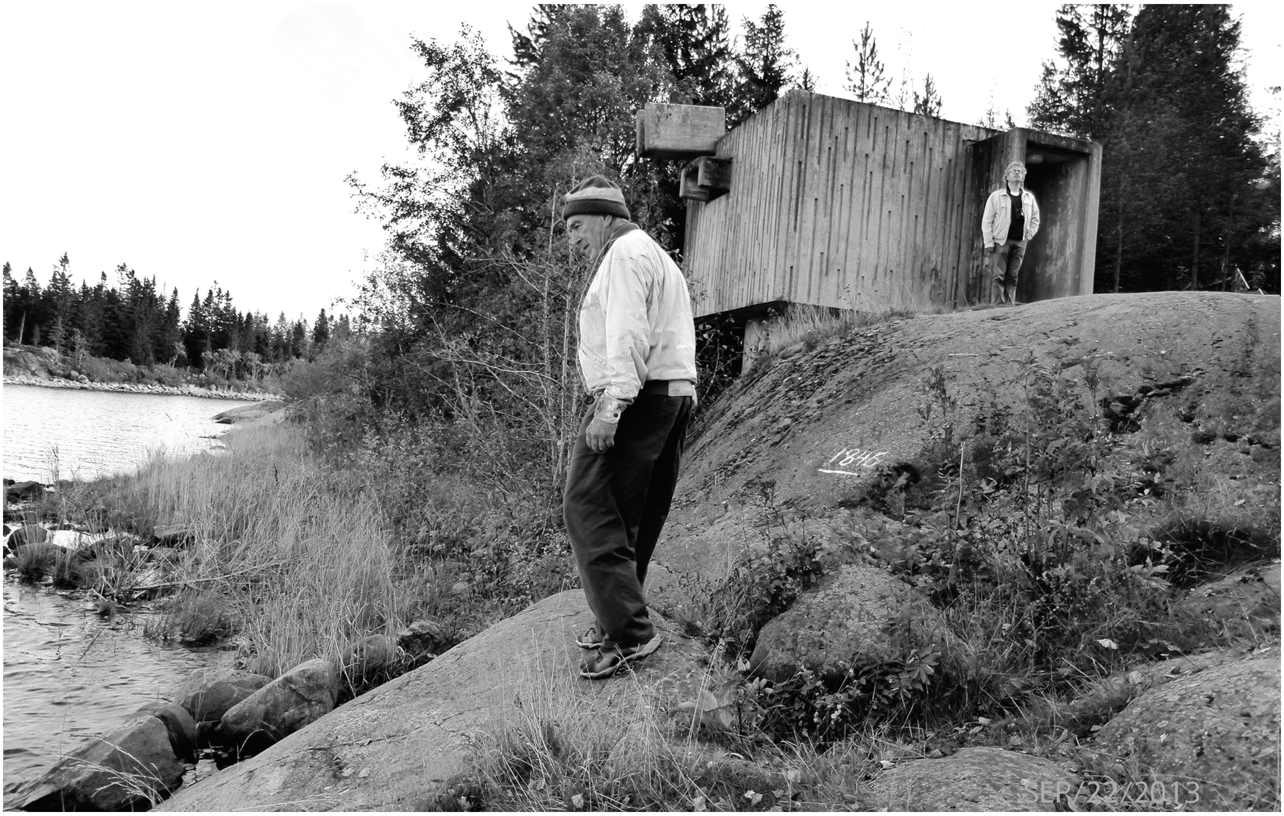

Figure 6. Sea level fall in the northern Gulf of Bothnia along the northeast Swedish coast, showing the location of sea level in 1846 and the amount of fall since then

possibly aided by a lake ponded to the south, which would have lubricated the base during the surge. Surges and ice streams are believed to have existed at the edge of much of the Laurentide and Cordilleran Ice Sheets.[35]

In the creationist Ice Age model, surges would be much faster and more frequent since it is likely that most, if not all, the ingredients necessary for fast ice movement existed.[48,49] These ingredients are soft deformable basal sediments, 'warm' ice, impurities, a steep southerly slope that would thin after the surge, and large amounts of basal water. Although the slope on the Des Moines lobe was relatively low, it is possible that the slope was steep in Minnesota or southern Canada before surging, and flattened out during surging.

Moreover, driftless areas that were *never* glaciated in southern Saskatchewan and adjacent northeast Montana,[50] and southwest Wisconsin and vicinity[51] (figure 3), show the ice was quite thin in the surrounding areas. Besides a lack of glacial debris, the surface has vertical erosional remnants of St Peter Sandstone (figure 4) that would have been planed off by at least the last few 'ice ages'. The marginal lobes and the two driftless areas imply that the ice thickness was about one fifth that expected along the margin of an Antarctic-type ice sheet. Ice flow direction indicators show that ice sheet movement at the edge was strongly influenced by the low topographic features below the ice, reinforcing the idea that the ice sheet margin was thin.[52]

The northwest margin of the Laurentide Ice Sheet was also apparently thin.[53] It was only the southeast margin that was relatively thick, although the exact thickness is unknown. Some think that the ice was only 800 m deep above msl in the mountainous areas of New England.[54] Of course, thicker ice is expected in New England and southeast Canada since this area was close to the water vapour source of the Atlantic Ocean and major storm tracks.[1] Regardless, the southeast margin of the Laurentide Ice Sheet was probably thinner than expected compared to an ice sheet like Antarctica.

The thickness of the northeast margin of the Laurentide Ice Sheet has been much debated, but a recent report claims that it was as thick as 1,600 m, which is 1,000–1,500 m thinner than used in glacial isostatic rebound models.[55]

Although information is limited, the edge of the Scandinavian Ice Sheet was also lobed and likely thinner than expected. Along the edge of the Baltic Sea Kalm found:

> "Thus, in the peripheral zone close to the LGM [Last Glacial Maximum], but also at Baltija (Vepsian) and South- and Middle Lithuanian margins the ice was divided into numerous small ice lobes with variable movement directions indicating a [sic] relatively thin

glacier that was conformed to the local topography."[56]

A later research report claimed that the southeast sector was thin to non-existent for at least part of the 'last' ice age.[57] Such a thin, lobed ice sheet edge could not occur if the Scandinavian Ice Sheet was as thick as Antarctica.

So, most of the marginal areas that can be estimated with any degree of accuracy show significantly thinner ice than expected by uniformitarians. When added to the evidence of more than one dome, the Laurentide Ice Sheet was apparently substantially thinner than many uniformitarian estimates.

Glacial isostasy indicates a thinner ice sheet

Glacial isostasy is the depression or rebounding of the earth's crust and upper mantle caused by the addition or subtraction, respectively, of an ice sheet (figure 5). The amount of crustal rebound after the ice melted, plus the estimated amount of rebound left to go, can provide a crude estimation of ice sheet volume. Both the Scandinavia and Hudson Bay regions have been rising since the end of the Ice Age. It is estimated that Hudson Bay has rebounded 315 m while Scandinavia has risen 290 m.[58,59] It has been roughly estimated that this former depression represents three times the height of the former ice sheets, which, by using the mean between the rebounds of Hudson Bay and Scandinavia, indicates an ice thickness of around 910 m. However, some estimate that half the rebound is caused by former ice sheets,[60] which would make the thickness of the ice only about 455 m. There are many complicating variables in such estimates, such as the viscosity of the mantle and the elastic thickness of the lithosphere.

Although some scientists believe isostatic uplift from melted ice sheets is about finished,[60] others believe these areas have not yet recovered. The Gulf of Bothnia in the Baltic Sea is currently rising about one cm per year (figure 6). So, it is difficult to obtain an accurate estimate of the remaining amount of rebound from melted ice sheets. Some scientists estimate that Hudson Bay and the northern Gulf of Bothnia will rise another 100 to 200 m.

If we were to take the most pessimistic numbers for glacial rebound in the past and expected in the future, then we would expect about 500 m of total rebound, which translates into about 1,500 m of ice in these areas. Although this estimate is uncertain and likely too high, based on several assumptions, it is still only about one third the generally accepted thickness of the Laurentide Ice Sheet in the single dome model.

Estimates based on oxygen isotopes

Another rather indirect method of estimating ice volume is to use the oxygen isotope ratios of carbonate minerals from the shells of foraminifera in deep sea cores. However, the equation that relates these measurements to ice volume has two unknowns, the temperature at which the carbonate was added to the shell and the original oxygen isotope ratio of the sea water. The latter variable is assumed to be related to ice volume. However, there are numerous other variables and complications in using this method.[61,62] Clark *et al.* remind us: "However, other factors (temperature, local salinity) that affect the isotopic signal measured in carbonate fossils partially obscure the ice volume component."[63]

Summary

Although many uniformitarian scientists persist in assuming that the Laurentide Ice Sheet was as thick as Antarctica, more direct field evidence from the interior and margins strongly suggest that the Laurentide Ice Sheet was significantly thinner. Since this ice sheet was by far the largest of all extinct ice sheets in Earth history, it is reasonable to conclude that the other ice sheets were thinner also. Evidence that the Cordilleran and Scandinavian Ice Sheets were also thinner was presented above. A total ice volume during the Ice Age significantly less than most uniformitarian estimates implies that sea level was not nearly as low as thought during glacial maximum, which is consistent with the creationist Ice Age model.[14]

References

1. Oard, M.J., *Frozen in Time: Woolly Mammoths, the Ice Age, and the Biblical Key to Their Secrets*, Master Books, Green Forest, AR, 2004.
2. Vernekar, A.D., Long-period global variations of incoming solar radiation, *Meteorological Monographs* **12**(34), American Meteorological Society, Boston, MA, 1972.
3. Rose, K.C., Ferraccioli, F., Jamieson, S.S.R., Bell, R.E., Corr, H., Creyts, T.T., Braaten, D., Jordan, T.A., Fretwell, P.T. and Damaske, D., Early East Antarctic Ice Sheet growth recorded in the landscape of the Gamburtsev subglacial mountains, *Earth and Planetary Science Letters* **375**:1–12, 2013.
4. Bierman, P.R., Corbett, L.B., Graly, J.A., Neumann, T.A., Lini, A., Crosby, B.T. and Rood, D.H., Preservation of a preglacial landscape under the center of the Greenland Ice Sheet, *Science* **344**:402–405, 2014.
5. Tabor, C.R., Poulsen, C.J. and Pollard, D., Mending Milankovitch's theory: obliquity amplification by surface feedbacks, *Climates of the Past* **10**:41–50, 2014.
6. Oard, M.J., The astronomical theory of the Ice Age becomes more complicated, *J. Creation* **19**(2):16–18, 2005.
7. Oard, M.J., Astronomical troubles for the astronomical hypothesis of ice ages, *J. Creation* **21**(3):19–23, 2007.
8. Walker, M. and Lowe, J., Quaternary science 2007: a 50-year retrospective, *J. Geological Society London* **164**:1073–1092, 2007.
9. Hebert, J., Circular reasoning in the dating of deep seafloor sediments and ice cores: the orbital tuning method, *Answers Research J.* **7**:297–309, 2014.
10. Oard, M.J., *The Frozen Record: Examining the Ice Core History of the Greenland and Antarctic Ice Sheets*, Institute for Creation Research, Dallas, TX, 2005.
11. Oard, M.J., (ebook) *Earth's Surface Shaped by Genesis Flood Runoff*, michael.oards.net?GenesisFloodRunoff.htm, 2013.
12. Huybrechts, P., Steinhage, D., Wilhelms, F. and Bamber, J., Balance velocity and measured properties of Antarctic ice sheet form a new compilation of gridded data for modelling, *Annals of Glaciology* **30**:52–60, 2000.
13. Cuffey, K.M. and Marshall, S.J., Substantial contribution to sea-level rise during the last interglacial from the Greenland Ice Sheet, *Nature* **404**:591–594, 2000.
14. Oard, M.J., *An Ice Age Caused by the Genesis Flood*, Institute for Creation Research, Dallas, TX, 1990.
15. Clark, P.U. and Mix, A.C., Ice sheets by volume, *Nature* **406**:689, 2000.

16. Bloom, A.L., Glacial-eustatic and isostatic controls of sea level; in: Turekian, K.K. (Ed.), *The Late Cenozoic Glacial Ages*, Yale University Press, New Haven, CT, p. 367, 1971.
17. Andrews, J.T., On the reconstruction of Pleistocene ice sheets: a review, *Quaternary Science Reviews* **1**:12, 1982.
18. Bonelli, S., Charbit, S., Kageyama, M., Wiollez, M.-N., Ramstein, G., Dumas, C. and Quiquet, A., Investigating the evolution of major Northern Hemisphere ice sheets during the last glacial-interglacial cycle, *Climate of the Past* **5**:329–345, 2009.
19. Christoffersen, P., Tulaczyk, S., Wattrus, N.J., Peterson, J., Quintana-Krupinski, N., Clark, C.D. and Sjunneskog, C., Large subglacial lakes beneath the Laurentide Ice Sheet inferred from sedimentary sequences, *Geology* **36**(7):563, 2008.
20. Peltier, W.R., Postglacial variations in the level of the sea: implications for climatic dynamics and solid-Earth geophysics, *Reviews of Geophysics* **36**:603–689, 1998.
21. Cuffey, K.M. and Patterson, W.S.B., *The Physics of Glaciers*, 4th edn, Butterworth-Heinemann, Amsterdam, p. 296, 2010.
22. Tarasov, L. and Peltier, W.R., A geophysically constrained large ensemble analysis of the deglacial history of the North American ice-sheet complex, *Quaternary Science Reviews* **23**:359–388, 2004.
23. Tarasov and Peltier, ref. 22, p. 359.
24. Milne, G.A., Mitrovica, J.X. and Schrag, D.P., Estimating past continental ice volume from sea-level data, *Quaternary Science Reviews* **21**:361–376, 2002.
25. Flint, R.F., *Glacial and Quaternary Geology*, John Wiley and Sons, New York, pp. 317–318, 1971.
26. Oard, M.J., *Ancient Ice Ages or Gigantic Submarine Landslides?* Creation Research Society Books, Chino Valley, AZ, 1997.
27. Oard, M.J., The reinforcement syndrome ubiquitous in the earth sciences, *J. Creation* **27**(3):13–16, 2013.
28. Andrews, ref. 17, pp. 1–30.
29. Greenwood, S.L. and Kleman, J., Glacial landforms of extreme size in the Keewatin sector of the Laurentide Ice Sheet, *Quaternary Science Reviews* **29**: 1894–1910, 2010.
30. Andrews, ref. 17, p. 10.
31. Shilts, W.W., Cunningham, C.J. and Kaszycki, C.A., Keewatin Ice Sheet—re-evaluation of the traditional concept of the Laurentide Ice Sheet, *Geology* **7**:537–541, 1979.
32. Hillaire-Marcel, C., Grand, D.R. and Vincent, J.S., Comments and reply on Keewatin Ice Sheet—re-evaluation of the traditional concept of the Laurentide Ice Sheet and glacial erosion and ice sheet divides, northeastern Laurentide Ice Sheet, on the basis of distribution of limestone erratics, *Geology* **8**:466–467, 1980.
33. Shilts, W.W., Flow patterns in the central North American ice sheet, *Nature* **286**: 213–218, 1980.
34. Bonelli *et al.*, ref. 18, p. 337.
35. Kleman, J., Jansson, K., De Angelis, H., Stroeven, A.P., Hättestrand, C., Alm, G. and Glasser, N., North American Ice Sheet build-up during the last glacial cycle, 115–21 kyr, *Quaternary Science Reviews* **29**:2036–2051, 2010.
36. Klemen *et al.*, ref. 35, p. 2036.
37. Otieno, F.O. and Bromwich, D.H., Contribution of atmospheric circulation to inception of the Laurentide Ice Sheet at 116 kyr BP, *J. Climate* **22**:39–57, 2009.
38. Tamisiea, M.E., Mitrovica, J.X. and Davis, J.L., GRACE gravity data constrain ancient ice geometries and continental dynamics over Laurentia, *Science* **316**: 881–883, 2007.
39. Andrews, ref. 17, p. 1.
40. Occhietti, S., Laurentide Ice Sheet: oceanic and climatic implications, *Palaeogeography, Palaeoclimatology, Palaeoecology* **44**:1–22, 1983.
41. Lopez, D.A., Geology of the Sweet Grass Hills, North-Central Montana, *Montana Bureau of Mines and Geology Memoir 68*, Montana Bureau of Mines and Geology, Butte, MT, 1995.
42. Lemke, R.W. *et al.*, Glaciated area east of the Rocky Mountains; in: Wright, Jr, H.E. and Frey, D.C. (Eds.), *The Quaternary of the United States*, Princeton University Press, Princeton, NJ, pp. 15–26, 1965.
43. Mathews, W.H., Surface profiles of the Laurentide Ice Sheet in its marginal areas, *J. Glaciology* **13**(67):37–43, 1974.
44. I have concluded that the early glaciologists mistook water-laid glacial debris for grounded ice sheets and so claimed that the Laurentide Ice Sheet extended as far as northeast Kansas and northern Missouri in the Midwest of the United States.
45. Clark, P.U., Surface form of the southern Laurentide Ice Sheet and its implications to ice-sheet dynamics, *GSA Bulletin* **104**:595–605, 1992.
46. Hooyer, T.S. and Iverson, N.R., Flow mechanism of the Des Moines lobe of the Laurentide ice sheet, *J. Glaciology* **48**(63):575–586, 2002.
47. Oard, M.J., Long-age puzzle of thin ice at the edge of the Laurentide Ice Sheet, *J. Creation* **18**(2):5–6, 2004.
48. Horstemeyer, M.F. and Gullet, P., Will mechanics allow a rapid Ice Age following the Flood?; in: Ivey, Jr, R.L. (Ed.), *Proceedings of the Fifth International Conference on Creationism*, Creation Science Fellowship, Pittsburgh, PA, pp. 165–174, 2003.
49. Sherburn, J.A., Horstemeyer, M.F. and Solanki, K., Simulation analysis of glacial surging in the Des Moines ice lobe; in: Snelling, A.A. (Ed.), *Proceedings of the Sixth International Conference on Creationism*, Creation Science Fellowship and Institute for Creation Research, Pittsburgh, PA, and Dallas, TX, pp. 263–273, 2008.
50. Klassen, R.W., Late Wisconsinan and Holocene history of southwestern Saskatchewan, *Canadian J. Earth Sciences* **31**:1822–1837, 1994.
51. Riewe, T., The 'driftless area': a puzzle to geologists, geographers, and drillers, *Water Well J.*, February 2001.
52. Clayton, L., Teller, J.T. and Attig, J.W., Surging of the southwestern part of the Laurentide Ice Sheet, *Boreas* **14**:235–241, 1985.
53. Beget, J., Low profile of the northwest Laurentide Ice Sheet, *Arctic and Alpine Research* **19**:81–88, 1987.
54. Caldwell, D.W. and Hanson, L.S., The nunatak stage on Mt. Katahdin, northern Maine, persisted through the Late Wisconsinan, *GSA Abstracts with Programs* **18**:8, 1986.
55. Simon, K.M., James, T.S. and Dyke, A.S., A new glacial isostatic adjustment model of the Innuitian Ice Sheet, Arctic Canada, *Quaternary Science Reviews* **119**: 11–21, 2015.
56. Kalm, V., Ice-flow pattern and extent of the last Scandinavian Ice Sheet southeast of the Baltic Sea, *Quaternary Science Reviews* **44**:55, 2012.
57. Räsänen, M.E., Huitti, J.V.,Bhattarai, S. and Harvey III, J., The SE sector of the Middle Weichselian Eurasian Ice Sheet was much smaller than assumed, *Quaternary Science Reviews* **122**:131–141, 2015.
58. Eronen, M., Late Weichselian and Holocene shore displacement in Finland; in: Smith, D.E. and Dawson, A.G. (Eds.), *Shorelines and Isostasy*, Academic Press, New York, pp. 183–207, 1983.
59. Fairbridge, R.W., Isostasy and eustasy; in: Smith, D.E. and Dawson, A.G. (Eds.), *Shorelines and Isostasy*, Academic Press, New York, pp. 3–28, 1983.
60. Mitrovica, J.X., Going halves over Hudson Bay, *Nature* **390**:444–447, 1997.
61. Oard, M.J., Ice ages: the mystery solved? Part II: the manipulation of deep-sea cores, *Creation Research Society Quarterly* **21**(3):125–137, 1984.
62. Oard, M.J. and Reed, J.K., Cyclostratigraphy and Astrochronology Part III: Critique of the Milankovitch Mechanism, *Creation Research Society Quarterly* (in press).
63. Clark, P.U., Mix, A.C., Bard, E., Ice sheets and sea level of the last glacial maximum, *EOS, Transactions, American Geophysical Union* **82**(22):241, 246–247, 2001.

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