THE HISTORY OF DEVILS LAKE, WISCONSIN

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The vicinity of Devils Lake, Wisconsin, has long been used as a field of instruction in geology in the Middle West. The pre-Cambrian igneous, sedimentary, and metamorphic rocks, the Paleozoic history, the economic products, the general results of glaciation, the origin and history of the lake, have all been reported in a general way.[1] It has been the privilege of the writer to conduct several courses in the district, to work over the data collected and reported by previous investigators, and to work out additional points not completed by them. He finds that the general history of the district may be incorporated in an account of the history of the lake and its basin.

The purpose of this paper is to bring together all the events in the history of the lake basin, and to include some heretofore unpublished conclusions as to the history of the lake, its past and present sources of supply, and outlets once established but now abandoned. This involves repetition of some facts already published, and leads beyond the present boundaries of the lake basin.

LOCATION AND DESCRIPTION

Devils Lake is an almost rectangular body of fresh water $1\frac{3}{10}$ miles long in a north-south direction and $\frac{1}{2}$ mile broad, situated in Sauk County, Wisconsin, 3 miles south of Baraboo, 40 miles north by northwest of Madison, 80 miles southeast of LaCrosse, and 100 miles west by northwest of Milwaukee.

The district in which the lake lies is one of extraordinary high relief for the central Mississippi Basin (about 800 feet) and of considerable irregularity. The topography is dominated by two

[1] R. D. Salisbury and W. W. Atwood, *Bull. No. 5, Wis. Geol. and Nat. Hist. Surv.*, pp. 51–55; Samuel Weidman, *Bull. No. 13, ibid.*, pp. 109–14; Lawrence Martin, *Bull. No. 36, ibid.*, pp. 177–78.

ridges or "ranges," known respectively as the North Range and the South Range. These are the outcropping edges of the hard Baraboo quartzite formation which forms here an asymmetric syncline, the north limb of which is nearly vertical and forms the North Range and the south limb of which has an average dip of 18° and forms the broader and higher South Range. The ranges are 24 miles long in a general east-west direction, and they converge at either end. The South Range is distinctly flat at and near the top, the plain summit areas lying between 1,400 and 1,480 feet A.T. There are also smaller areas of flattish land at 1,200 feet, 400 feet below Sauk Point, which is the highest point in the district, and 400 feet above main drainage lines. The summit of the North Range is also flattish, its evelation being about 1,200 feet.

The district is drained by the Wisconsin and Baraboo rivers and their tributaries. The Wisconsin River flows from the Dells, 17 miles north of Baraboo, in a broad curve past the east end of the ranges at Portage to Prairie du Sac, where it may be said to leave the district. Baraboo River enters the district at Ableman through the North Range, in a gap known as the Upper Narrows, flows in a general easterly direction between the ranges past Baraboo, cuts back through the North Range at the Lower or Baraboo Narrows, and joins the Wisconsin River near Portage.

Devils Lake occupies the northern portion of the only gap there is through the South Range. This gap has the form of a broad open curve with a north-south course in its northern portion, an east-west course in the middle of the range, and a northwest-southeast course at the south edge of the range. About one-fourth of the length of the gap is occupied by the lake. The surface of the lake is at 960 feet A.T. which is 160 feet above the Baraboo River to the north, 200 feet above the Wisconsin River to the south, and about 500 feet lower than the flat top of the range east, west, and southeast of it (Plate I).

STRATIGRAPHY

The rocks of the district about Devils Lake include the Huronian, Cambrian, and Ordovician, each system being represented by more than one formation.

The oldest rocks of the district are granite, diorite, and rhyolite, which lie around the borders of the quartzite syncline and seem to form the basement upon which the quartzite was deposited. Next above the igneous rocks lies the Baraboo quartzite, which in turn is overlain conformably by the Seeley slate and the Freedom formation. The Baraboo, Seeley, and Freedom formations are all involved in the folded structure of the district, although the Seeley and Freedom beds do not outcrop. The total thickness of the Proterozoic formations is about 6,000 feet, the quartzite alone measuring in the North and South ranges about 5,000 feet.

There is a great unconformity between the Proterozoic and Paleozoic groups of rock. After the Proterozoic formations were deposited and folded, the region was eroded in one or more cycles until the surface in this district had a relief of at least 1,300 feet, and upon this rugged surface the Cambrian rocks were deposited.

The Cambrian system includes the Potsdam sandstone, between 600 and 700 feet thick where thickest, the Mendota limestone, 3–11 feet thick in the Devils Lake district, and the Madison sandstone, 80–90 feet thick. This is a conformable series and the strata are essentially horizontal. Away from the ranges the top of the Madison sandstone is about 1,020 A.T., but the standsone laps up on the ranges to altitudes of 1,200 feet or higher.

Only the Prairie du Chien and St. Peter formations of the Ordovician system now appear in the vicinity of Devils Lake, although it is nearly certain that younger formations were deposited here originally and have been eroded away.

The Prairie du Chien formation overlies the Madison sandstone conformably, but outcrops in only a few localities within the boundaries of the Devils Lake district. It is hard, cherty dolomite. Its average thickness in the Mississippi Valley is about 200 feet, although in the immediate vicinity of Devils Lake its greatest thickness is 20 feet.

An unconformity is known to exist between the St. Peter and Prairie du Chien formations in Iowa, Illinois, Wisconsin, and Minnesota, and is well represented in the Devils Lake district. If the total thickness of 200 feet of Prairie du Chien dolomite was deposited here, all but 20 feet was eroded away a mile southeast of the Baraboo Narrows, before the deposition of the St. Peter sandstone. At Gibraltar Rock, 8 miles southeast of Devils Lake, there is a thickness of 73 feet of Prairie du Chien dolomite between the St. Peter and Madison sandstones on the southeast slope of the hill and none at all on the southwest slope, the St. Peter sandstone lying directly on the Madison sandstone on the southwest side. It is believed that the Prairie du Chien dolomite was entirely removed in other places also, before the St. Peter sandstone was deposited, as on the hill a mile south of the Pewits Nest (see Plate II). The St. Peter formation is a massive, medium-grained, quartz formation so similar to the Madison that the two cannot be separated on lithologic grounds. The St. Peter sandstone is thought by some geologists to be of eolian origin, but most of it at least seems to be marine. In thickness the St. Peter varies from a few feet to more than 200 feet within the district. The variation is due to the erosion surface on which it lies, and to post-St. Peter erosion of its surface.

Platteville limestone, Galena dolomite, and Maquoketa shale are all found at Blue Mounds, 26 miles to the south of Devils Lake, and its seems certain that these formations once covered the Devils Lake district. If so, they were eroded away in some late Paleozoic, Mesozoic, or Cenozoic erosion cycle, leaving no trace of their previous existence.

The previous existence of rocks of Silurian age in the district is proved by the finding of Niagaran fossils in a gravel deposit on the summit of the quartzite range east of Devils Lake.[1]

Aside from the late Ordovician and mid-Silurian rocks which once undoubtedly covered the region around Devils Lake, it is entirely possible, though not proved, that formations of Devonian and Carboniferous age were deposited also and were subsequently eroded away. Certain it is that thick deposits of rock were laid over the St. Peter sandstone.

Glacial drift and lacustrine deposits of late Pleistocene age lie unconformably on all the older rocks of the district (Plate II).

[1] R. D. Salisbury, *Jour. Geol.*, III, 655–67.

THE EARLIEST RECORD

The history of the depression in which Devils Lake lies goes back to pre-Cambrian times. Cambrian sandstone lies in the gap, (1) at the north end of the east bluff one mile south of the northernmost outcrop of quartzite in the South Range, 240 feet above lake-level and 270 feet below the summit plain; (2) near the foot of the west bluff, one-fourth mile north of the north end of the lake, 60 feet above lake-level and 450 feet below the tops of the bluffs; (3) at the southwest corner of the lake at "Messenger's End," where it extends from a few feet above lake-level to an altitude of 1,200 feet at the divide between Devils Lake and Skillett's Creek; and (4) forming a hill or bluff on the north wall of the gap 2½ miles east of the lake. At the last-designated point the sandstone extends to 900 feet A.T., which is below lake-level. The presence of Cambrian sandstone at levels near that of the present lake surface, near the north end, near the southeast end, and near the center of the gap shows clearly that there was a depression or that there were depressions here before the advance of the Cambrian sea. The facts might be interpreted in one of two ways:

1. The simplest explanation lies in the assumption that after the pre-Cambrian formations were folded, the surface was eroded and reduced to a peneplain on which a river meandered, that this plain was uplifted relative to the sea, and that the district had reached late youth or early maturity in a second cycle of erosion before submergence by the Cambrian sea. Under this interpretation the original gap is a pre-Cambrian intrenched meander. The ancient peneplain may be represented by the present summit plain of the district, or it may have been entirely destroyed in subsequent periods of erosion.

2. The conditions, however, might be almost equally well explained by assuming that the district was in maturity either of its first or of some later cycle of erosion when the Cambrian sea advanced, that at that time a deep valley existed in the range with its head in the valley of Messenger's Creek and discharging eastward and southeastward, and that another stream headed somewhere north of Messenger's Creek and flowed northward into the Baraboo valley. This would not necessitate more than one cycle of

erosion in pre-Cambrian times nor would it preclude more than one cycle.

After the long series of events during the Paleozoic and subsequent history of the district, it does not seem possible to determine which of the foregoing interpretations is correct. However, some light is thrown upon the matter by consideration of the pre-Cambrian history of Wisconsin, and the principles of stream adjustment. It has been demonstrated by Weidman[1] and Martin[2] that the surface of Wisconsin was degraded to a peneplain in pre-Cambrian times, that this plain slopes south and is buried beneath Cambrian sediments at an altitude of about 300 feet in the latitude of Devils Lake, and that the quartzite ranges stood as erosion remnants on this plain. Well-records in the Baraboo valley show that the pre-Cambrian surface within the inclosure made by the ranges is as low at least in some places as 340 feet A.T. A stream must therefore have had entrance to the inclosure and a means of escape from it. A broad, continuous, stream-made gap, filled with Cambrian sediments, cuts through the North Range northwest of Baraboo, and is probably the line of entrance or exit of a large pre-Cambrian stream. The other gap, either entrance or exit, is not known unless it be the Devils Lake gap. Neither the Lower nor the Upper Narrows seems to be large enough and they have not yet been proved to be pre-Cambrian in age. It is improbable that there is a buried gap, undiscovered, either in the North or the South Range, which might have conducted the river in or out of the area between the ranges. It is unlikely also that two streams would adjust themselves as postulated in the second case above. A stream working headward into a hard, high ridge with a steep slope would hardly develop a course other than one more or less nearly straight and nearly normal to the trend of the ridge. But the stream flowing southeastward from Messenger's Creek must have had a course which was distinctly curved, had supplementary angles of 30° and 150° with the trend of the ridge, and was oblique to the dip of the rocks. On the other hand, the

[1] Samuel Weidman, *Bull. 16, Wis. Geol. and Nat. Hist. Surv.*, pp. 385–95, 592–600; *Jour. Geol.*, XI, 289–313.

[2] Lawrence Martin, *Bull. 36, Wis. Geol. and Nat. Hist. Surv.*, pp. 347–73.

freshness and apparent youth of Devils Lake gap, and its size, harmonious with the dimensions of the Upper and Lower Narrows, suggest that these three gaps were cut at the same time and during some post-Silurian period. And yet Devils Lake gap may have carried a large river in pre-Cambrian times and the gap may have been reoccupied at a later time when the two Baraboo narrows were cut.

Whether the pre-Cambrian Devils Lake gap was cut by a single intrenched meandering stream, or by two streams with a col between them, the depression must have been a deep one. The rim of the canyon is today represented by the 1,470-foot summit plain, and the pre-Cambrian rim may have been higher than this. Cambrian sandstone in the gap is known as low as 900 feet A.T. The depression must therefore have been at least 570 feet deep in pre-Cambrian times. Certainly if the gap was cut by the same stream which reduced the inclosure between the ranges to 340 feet A.T., and probably if it was cut by two streams tributary to main drainage, the bottom of the gap at the end of pre-Cambrian times was not much higher than 340 feet A.T. The pre-Cambrian gap was then probably not far from 1,100 feet deep. The whole district at this time is known to have had a relief of 1,200 or 1,300 feet.

PALEOZOIC HISTORY

The Paleozoic, marine, sedimentary rocks of the district record the second important step in the known history of the district.

Upper Cambrian sandstone is found on the ranges to an altitude of 1,200 feet A.T. and probably exists at slightly higher levels. On Wood's Quarry Hill, 3 miles northwest of the lake, rounded pebbles of quartzite are found in the uppermost beds of the Madison formation where it is overlain conformably by Ordovician dolomite, giving evidence that quartzite was exposed on near-by land up until the very end of the Cambrian period. In the light of these facts, it is believed that the South Range was an island in the Cambrian sea, and that the Devils Lake gap was not filled to a higher level than 1,020 feet, although the sea seems to have reached at least to 1,200 feet.

But deposition did not end with the Cambrian period. The Prairie du Chien and St. Peter formations, or their time equivalents, must have been deposited in the gap. It is clear that the sediments of the Prairie du Chien stage did not fill the gap, for the base of this formation has an elevation of 1,020 feet in the vicinity, and it would require a thickness of 500 feet to have filled the gap. As the formation is nowhere known to be so thick, it is probable that a sag existed at the site of the present gap, when the Prairie du Chien sea had withdrawn, and it is possible that the gap was again occupied by running water and partly re-excavated before the deposition of the St. Peter sandstone. As the St. Peter sandstone is not found much above 1,300 feet in the district, it seems clear that the gap was not entirely filled with this deposit.

Although no traces of the Platteville, Galena, and Maquoketa formations are found in Devils Lake gap or in its immediate vicinity, it seems clear that these formations, or their time equivalents, were deposited in the gap, filled it, and buried it, for if the dip of these formations be projected northward from their existing altitude at Blue Mounds and other points to the south, the bottom of the Maquoketa formation would lie 200 or 300 feet above the summit plain on the South Range. Gravels containing Niagaran fossils are found to the very top of the range on the flat summit plain east of the lake, showing that this formation added its thickness to the sediments which buried the filled gap and the ranges.

If still younger Paleozoic formations were deposited over the district and over the filled gap, they have left no record. So far as the records go, the Paleozoic sea retreated finally at some date after the Niagaran epoch. These seas probably left the district essentially flat, with the rough surface of the quartzite buried beneath thick Paleozoic sediments. At this time there was no Devils Lake gap as a topographic feature, but there was a previously existing gap, filled with sediments and buried by formations which also covered the ranges deeply.

POST-PALEOZOIC—PRE-GLACIAL HISTORY

The record of the history of the gap following the final withdrawal of the Paleozoic seas and antedating the advance of the

Wisconsin glacier is to be read only from the study of the topography and surficial deposits of this and surrounding districts.

The flat summit areas at various places on the South Range at altitudes between 1,400 and 1,480 feet, lying across the beveled edges of the quartzite beds, can be interpreted only as an ancient plain of degradation now almost destroyed by streams working in a later erosion cycle. The peneplain might be considered to be of pre-Cambrian age but for the fact that there are stream gravels on its surface which are composed of Paleozoic rocks, and contain fragments in which are imbedded Niagaran fossils. Associated with the gravel there are numbers of potholes which are not filled by Paleozoic sediments and which probably are of post-Niagaran age. The idea that the flat is a remnant of the old pre-Cambrian plain buried by Paleozoic formations, resurrected by later erosion, and becoming again the site of deposition as a part of the later peneplain, is perhaps tenable, although hardly probable, for the extension of this plain has now been traced west into Iowa and south into Illinois, in both of which states it cuts across the beveled edges of the Potsdam, Prairie du Chien, St. Peter, Platteville, Galena, and Niagara formations in order.

It is not to be understood that this erosion surface had reached a final stage of degradation and was perfectly flat. It is made clear by a study of the Devils Lake district, as of other districts where the plain is known, that it had considerable relief. West of Devils Lake the surface of the plain is 1,400 feet A.T., which seems to be the altitude of the portion which was brought to grade. East of the lake the gravels lie on a flattish surface at 1,470 feet, and quartzite at Sauk Point reaches an altitude of about 1,600 feet. Before this surface was dissected, it had a relief of 200 feet in the Devils Lake district, and the gravel occupies a position between the lowest and highest portions of the surface. The gravels probably were not brought from a distance by a long and large stream at grade, but were more likely to have been deposited by a stream tributary to main drainage, the tributary having enough velocity to carry gravel and to cut potholes. The gravels include no material which could not have been derived from local formations. On the other hand, the relief of the surface must have been much less than that of the present surface, and Devils Lake gap could not have existed at the time.

The exact age of this erosion surface is still an open question. Where the plain and the gravel associated with it are known outside this district, they have been assigned by different writers to different ages. Winchell[1] long ago correlated these gravels in Minnesota tentatively with the Cretaceous, and following his lead Bain,[2] Calvin,[3] Grant and Burchard,[4] Hershey,[5] and others have considered the plain to have been formed chiefly during the Cretaceous period. This correlation is, however, somewhat doubtful, for the reason that it has never been proved that the gravel on the plain in Minnesota is of Cretaceous age. It seems to lie on the Cretaceous, a relationship which tends to show that the plain cuts across the edges of the eroded Cretaceous rocks and is therefore post-Cretaceous in age, just as the fact that it cuts across the Paleozoic sediments proves that it is younger than those sediments. Most likely the plain is of Tertiary age. The evidence of this has been presented by Salisbury[6] in an article in which he suggests the correlation of these patches of gravel with the Lafayette formation farther south.

It is at least clear that the Devils Lake gap remained filled with Paleozoic sediments while this plain was being formed, and that the time involved was long.

There are strong suggestions of a second flattish erosion surface with remnants at about 1,200 feet. Representatives of this surface may be found (1) cutting across the beveled edges of the vertical quartzite beds of the North Range at the Upper Narrows, (2) at the Lower Narrows, (3) 2 miles northeast of Denzer, (4) on the summit of Old Flat Top, 1 mile southeast of the Lower Narrows, (5) on the top of Gibraltar Rock, 1½ miles west of Okee, and (6) forming saddles or low divides in the South Range, as on the

[1] N. H. Winchell, *Geol. and Nat. Hist. Surv. Minn.*, I, 309–31, 353–56.

[2] H. F. Bain, *Bull. U.S. Geol. Surv., No. 294*, pp. 11–16.

[3] Samuel Calvin, *Iowa Geol. Surv.*, IV, 43.

[4] Grant and Burchard, Lancaster Mineral Point Folio, *U.S. Geol. Surv.*, p. 2.

[5] O. H. Hershey, *Am. Geol.*, XX, 246–59.

[6] R. D. Salisbury, *Jour. Geol.*, III, 655–67.

divides between the North Fork of Messenger's Creek and Skillett's Creek, between the South Fork of Messenger's Creek and an unnamed south-flowing stream, between Pine Creek and Otter Creek, etc. Because the remnants of this plain within the district cut across the quartzite beds and lie on St. Peter sandstone, and because most of the streams of the district find their sources on the plain, the remnants are believed to represent parts of a plain of erosion developed at this level, but now mostly dissected. This interpretation is greatly strengthened by the finding of a similar plain, bearing the same relation to the older plain, and cutting across the edges of eroded formations, at many places outside the district under consideration, as, for instance, in the Richland Center quadrangle, in the Sparta quadrangle, in the Lancaster and Mineral Point quadrangles, in the eastern portions of the Waukon and Elkader quadrangles in Wisconsin, in Jo Daviess County, Illinois, in Allamakee, Clayton, and Dubuque counties in Iowa, and at various places in southeastern Minnesota.[1]

If this plain is correctly interpreted, it records the following steps in the history of the district in general and of Devils Lake gap in particular. After the 1,400–1,480 foot plain was developed, the district was uplifted relative to the sea-level of that time to an amount of approximately 200 feet, the streams were rejuvenated, and reached grade again at levels 200 feet lower than the first plain.

It was during this cycle of erosion that Devils Lake gap was re-excavated and the Upper and Lower Narrows were formed, or re-formed if they are of pre-Cambrian age. In the formation of these post-Paleozoic gaps problems of stream adjustment are involved. Martin[2] expresses disbelief in the two peneplains in this part of the country, considers that all post-Niagaran and pre-Wisconsin erosion took place in a single cycle, and believes that the Devils Lake gap, and the two Baraboo gaps in the North Range,

[1] O. H. Hershey, *Am. Geol.*, XX, 246–59; U. B. Hughes, *Proc. Iowa Acad. Sci.*, XXIII, 125–32; W. D. Shipton, Master's thesis, University of Iowa Library; U. S. Grant and E. F. Burchard, Lancaster Mineral Point Folio, *U.S. Geol. Surv.*, p. 2; A. C. Trowbridge and E. W. Shaw, *Bull. No. 26, Ill. Geol. Surv.*, pp. 136–44; A. C. Trowbridge, *Bull. Geol. Soc. Am.*, XXVI, 76.

[2] Lawrence Martin, *Bull. No. 36, Wis. Geol. and Nat. Hist. Surv.*, pp. 63–70 and 177.

were made by the Wisconsin and Baraboo rivers developing their courses on the surface of the Paleozoic rocks, cutting down through these rocks and becoming superimposed on the ranges, and holding their courses. In the case of Devils Lake gap, at least, this hypothesis seems to involve too nice a coincidence. Whether the pre-Cambrian gap was continuous or made up of two valleys with a col between, Martin's idea would mean that a crooked stream starting on a surface 1,200 feet or more above final grade, cuts down more than 300 feet, then develops a flat surface and deposits fine gravel without ceasing to cut, is superimposed on quartzite in a course exactly coinciding with a peculiar pre-existing filled and buried crooked valley, and then cuts on downward for 900 feet without interruption.

It seems more likely to the writer that the explanation of the reoccupation of the gap by a stream is to be found in the application of the principle of stream adjustment on non-resistant rocks during a cycle of erosion which went nearly to completion. On the 1,400–1,480 foot surface, the streams flowed here on quartzite and there on sandstone. With the uplift of the surface, these streams began to intrench themselves and new tributaries were formed. The larger streams reached grade after cutting 200 feet or so. For most of the streams this downward cutting was through quartzite. The stream which adjusted on the non-resistant sandstone in the gap cut more rapidly than the others, obtaining an advantage in this way; it became a pirate and gradually captured many of the other streams. That there were other streams during this cycle and that they did intrench themselves before being captured is proved by the fact that there are passes or cols across the range at altitudes a little above 1,200 feet, as, for instance, where the West Sauk road crosses the range between the heads of Skillett's Creek and Otter Creek.

At any rate, it was during this cycle of erosion that the Wisconsin or its pre-Glacial ancestor came to flow southward and westward over the present site of the Lower Narrows, up the present course of the Baraboo valley and southward through the shallow Devils Lake gap, and the Baraboo River entered the inclosure between the quartzite ridges through the Upper Narrows, and joined the Wisconsin at about its point of entrance to Devils Lake gap. The Upper and Lower Narrows may have been formed for the first time by superimposition during the formation of the 1,200-foot plain, or possibly by adjustment of the streams on sandstone, provided they had been made and filled with sandstone.

The age of this lower plain and therefore the date of re-excavation of Devils Lake gap are no more proved than is the age of the upper erosional surface. Those who hold that the upper plain is Cretaceous assign a Tertiary age to the younger plain, and those who believe the upper plain to be Tertiary in age naturally assume that the lower plain was formed at the end of the Tertiary period or early in the Pleistocene. There is some evidence in northeastern Iowa that this plain was intact when the oldest glacial drift was deposited, but this also must be considered to be an open question until more of the field data have been published. At least it is clear that the present Devils Lake gap had its beginnings either in late Tertiary or in early Pleistocene times, which for present purposes is perhaps close enough.

Long before the monadnocks had been removed from this lower plain—that is, before the second cycle of erosion had reached completion—there was another uplift of the land relative to the then existing seas, and the streams were again rejuvenated. This uplift was much greater than the previous one, for the valleys cut during this third cycle of erosion are much deeper than any which were cut during the second cycle. At this time, too, the main part of the present Devils Lake gap was cut. The bottom of the gap at the beginning of this erosion cycle could not have been lower than 1,200 feet A.T. and the tops of the bluffs were no higher than 1,470 feet; that is, the maximum depth of the valley up to the beginning of the last erosion cycle preceding the deposition of the glacial drift was 270 feet. The maximum depth of the valley at the end of this cycle could be determined, if it were possible to get the altitude of bedrock underlying the glacial deposits in the middle of the gap, a bit of information which unfortunately is not available. The deepest boring into the glacial material within the gap was made by Gustaffson and Prader in 1914 at a point near the middle of the gap at the north end of Devils Lake, only a few feet above lake-level. The altitude of the well-site is about 965 feet. This well penetrates 283 feet of glacial material without striking rock; therefore the bottom of the pre-Glacial gap must be somewhere below 682 feet, and the pre-Glacial gap at this point must have been at least 788 feet deep, at least 500 feet deeper than it was at the end of the second erosion cycle, and at least 283 feet deeper than it is today. The maximum depth of this gap might be known if the altitude of the lowest sub-drift bedrock in the Baraboo valley between the ranges or in the Wisconsin valley south of the South Range could be obtained, assuming that a stream flowed from the Baraboo valley through the gap to the Wisconsin valley to the south. The lowest bedrock surface obtainable in the Baraboo valley east of Baraboo is at 570 feet. Assuming that the bedrock in the Devils Lake gap is as low, the pre-Glacial gap was at least 900 feet deep. It cannot be ascertained whether the pre-Cambrian gap was deeper than this or not so deep, for it cannot be determined whether there are Paleozoic sediments below the bottom of the present gap, nor whether the tops of the ranges were higher then than now. If it be true that the bottom of the pre-Cambrian gap lies at or near 340 feet, the pre-Cambrian gap was probably something like 200 feet deeper than the pre-Glacial gap.

THE GLACIAL LAKE

So far as ascertained, no glacier prior to the Wisconsin glacier affected the Devils Lake gap. There have been some suggestions of pre-Wisconsin drift in the vicinity,[1] but these evidences have proved to be negative. It seems likely, however, that the Illinoian glacier advanced almost to this district; but if it played any part in the history of the lake or its basin, its effects are not now visible within the district.

As has been brought out by Salisbury and Atwood,[2] the Wisconsin glacier formed Devils Lake and had a controlling influence in its early history. As the ice moved into the district from the northeast, it was divided by the ranges, one lobe advancing down the

[1] Samuel Weidman, *Bull. No. 13, Wis. Geol. and Nat. Hist. Surv.*, pp. 99–102.

[2] R. D. Salisbury and W. W. Atwood, *Bull. No. 5, Wis. Geol. and Nat. Hist. Surv.*, pp. 132–33.

old valley of the Wisconsin from the Lower Narrows to the north end of Devils Lake gap, where its edge became stationary and deposited a terminal moraine, the other lobe coming in south of the South Range and advancing up the valley of the pre-Glacial Wisconsin to deposit a marginal ridge across the gap east of its major bend (Plate II). This left the north-south portion of the gap and a part of the east-west portion confined between the two edges of the ice, and in the basin so made Devils Lake was formed. Connecting the ends of the two lobes, the edge of the ice reached its limits of advance in an irregular line crossing the South Range from the north edge of Devils Lake eastward to Sauk Point, and thence southwestward to the gap east of Kirkland (Plate II).

After its formation the lake had an interesting history during the occupancy of the ice.

Sources of supply.—When the lake was first formed, as outlined above, there were at least four separate sources of water supply: (1) The edge of the glacier blocked either end of the lake basin. There the ice melted and furnished water for the basin. Study of the terminal moraine from the north end of the lake around by Sauk Point and southwest to the gap east of Kirkland leads to the conclusion that the water resulting from melting along this whole stretch of ice front must have flowed into Devils Lake basin. (2) The bottom of the basin was below ground-water surface, as evidenced by the fact that it had been occupied by a permanent stream up to the time when this stream was blocked by the ice, and ground water was a source of supply. From the inception of the lake until its bottom was built up above ground-water surface by fluvio-glacial deposition, if this stage was ever reached, some of the lake water may have come from under ground. (3) The lake must have had inlets resulting from precipitation within the borders of the lake basin. For instance, Messenger's Creek with its north and south forks must have flowed into the southwest corner of the lake as it does today, and the stream which flows west and north past the northeast corner of the lake, being blocked to the north by the ice, must have contributed its waters to the lake. (4) There was doubtless direct precipitation upon the surface of the lake. Of these four sources of supply, the first mentioned is conceived to be most important, and needs more complete description.

From the extreme east end of the east loop of the terminal moraine at the west foot of Sauk Point, the land slopes south from the north limb of the moraine, north from the south limb, and west from the junction of the two limbs. The water formed by melting at the edge of the ice must therefore have concentrated in the depression between the two limbs of the moraine and must have

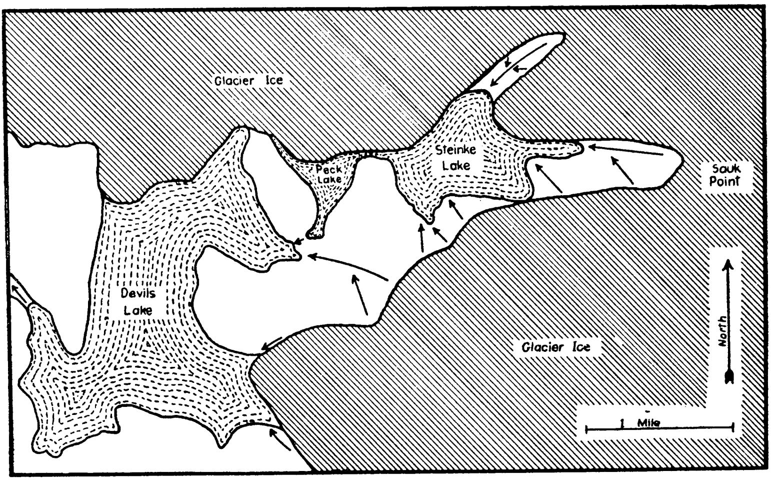


FIG. 1.—Sketch map showing Devils Lake and its drainage basin during the occupancy of the ice.

flowed westward into what has been called the Steinke Lake by Salisbury and Atwood[1] (see Fig. 1). The same general conditions existed in the minor loop north of the Steinke Lake, and the waters from this loop must have mingled with those from Sauk Point in the Steinke Lake.

The Steinke Lake was a body of water about $\frac{3}{4}$ mile long east and west and $\frac{1}{4}$ mile broad north and south, held in by a low ridge of quartzite on the west, the north limb of the ice edge on the north, the westward slope of the land from Sauk Point on the east, and the northward slope of the South Range and the south limb of the

[1] R. D. Salisbury and W. W. Atwood, *Bull. No. 5, Wis. Geol. and Nat. Hist. Surv.*, pp. 120, 133–34, Pl. XXXVII.

ice edge on the south. Short arms or bays projected east toward Sauk Point and north into the narrow loop of the ice edge. As discovered by Salisbury and Atwood, the lowest point in the basin of this extinct lake during the occupancy of the ice, and hence the head of the outlet of the lake, was at the extreme northwest corner of the lake a few rods across the Merrimac Road west of the home of Julius Steinke. The bottom of this outlet is at approximately 1,250 feet A.T., and as the outlet is broad and shallow, it may be assumed that the level of the lake was little if any above 1,260. The water from this lake flowed westward along the front of the ice toward Devils Lake.

The materials now occupying the site of this extinct lake are lacustrine silts, sands, and gravels, finely divided near the middle and coarser around the borders, and coarser at the surface than in the bottoms of deep cuts or borings. The maximum depth of the original lake is not known, but a well on the north side of the flat at the house next west of the schoolhouse, whose site is at 1,260 on lacustrine material, penetrates 202 feet of what appears to be lacustrine material, without reaching rock. This indicates that the original lake was at least 200 feet deep, and that the 200 feet of debris deposited in it was sufficient to fill the lake basin by the time of the retreat of the ice.

From the Steinke Lake the water drained westward into a small pocket or basin having a flat bottom. In late years this little plain has been known locally as the Peck flat. It is an area of perhaps 80 acres, bordering the terminal moraine on the north and sloping gently and getting narrower to the south. On the west, east, and south there are high hills of quartzite, but there is a break in the rim of the basin at its southwest corner, through which drainage is free to flow south and west to the north end of Devils Lake. The width and depth of this valley, the hardness of the quartzite which forms its walls and bottom, and the small size and intermittent character of the stream which drains it, when compared with the post-Glacial valleys of Skillett's Creek and the Wisconsin River, show that this outlet to Peck flat is pre-Glacial. Yet when all available authentic well-records are considered, it is clear that glacial waters could not have flowed at first through this outlet depression unobstructed. The accompanying table gives the altitudes of well-sites and rock outcrops, depths to sandstone, altitudes of bedrock, etc., for points located in Fig. 2.

TABLE OF WELLS AND OUTCROPS IN THE PECK BASIN

Wells and Outcrops	Altitude of Sight (Feet)	Depth to Sandstone (Feet)	Elevation of Sandstone Surface (Feet)	Depth to Quartzite (Feet)	Elevation of Quartzite Surface (Feet)
Johnson well...........	1,280	113	1,167	?	?
Peck drilled well........	1,225	38	1,187	?	?
Peck dug well..........	1,220	26+	1,194−	?	?
Iron drill hole..........	1,210	18	1,192	297+	913−
Marquid well...........	1,215	6	1,209	121+	1,094−
Steinke sandstone outcrop	1,205	0	1,205	?	?
Steinke quartzite outcrop	1,180	....	....	0	1,180
Steinke well............	1,218	6	1,212	155	1,063

From this table and from Fig., 3, it is made clear that the pre-Cambrian surface of this section, as of all portions of the district, was very irregular, and that the post-Paleozoic and pre-Glacial surface sloped north and west from opposite sides of a divide located somewhere near the south end of the present flat.

It is clear that the ice advancing from the north blocked drainage in that direction and melting, furnished water which joined with the discharge from Steinke Lake to make a small lake in the Peck basin. The waters of this lake rose rapidly to the level of the divide at the south end of the basin and overflowed westward into Devils Lake. Peck Lake, shallow from the first, was gradually filled until the lowest point on its bottom was as high as the outlet, and the lake ceased to exist. The filling of the lake must have been accomplished before the retreat of the glacier, for fluvio-glacial material was deposited over the lacustro-glacial material. The Peck dug well (see Fig. 2) penetrates 8 feet of coarse gravel and below that 18 feet of sand. The gravel is fluvio-glacial and the sand below lacustro-glacial. The top of the sand is at 1,212 feet A.T., and this is probably the approximate altitude of the pre-Glacial divide.

From the foregoing it is apparent that all the water from the edge of the glacier in its great complex loop east of Devils Lake flowed into Devils Lake during the occupancy of the ice (see Fig. 1).

The Size of Glacial Devils Lake.—After description of the sources of supply for the basin of Devils Lake during the occupancy of the

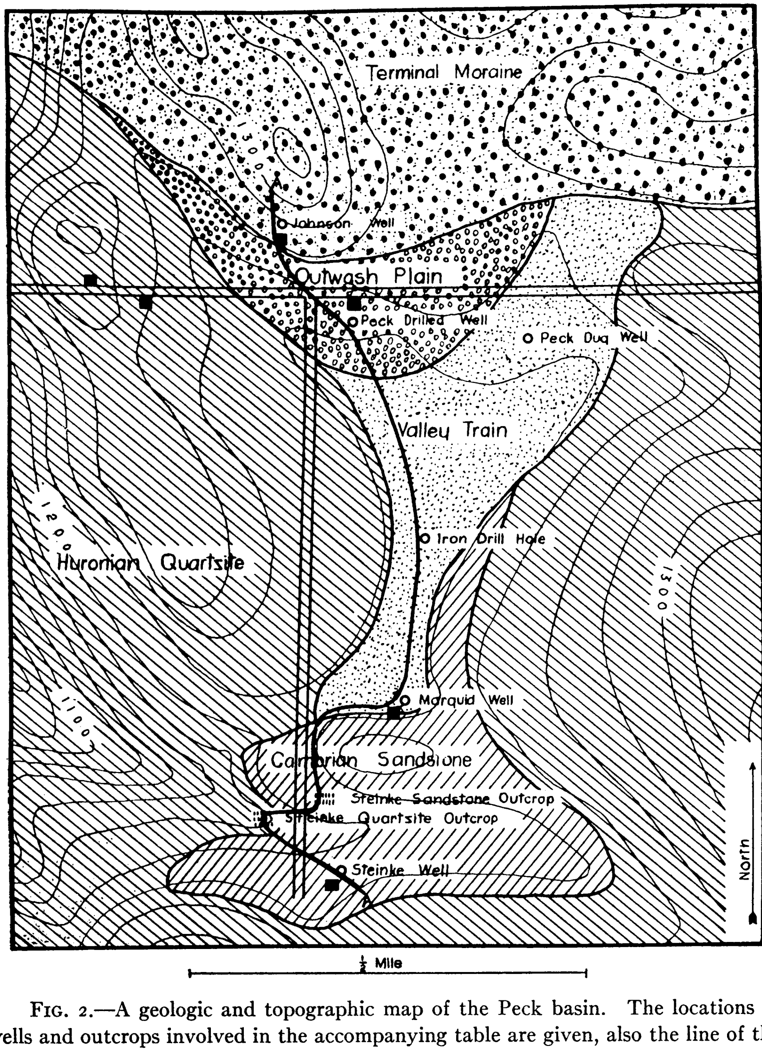


FIG. 2.—A geologic and topographic map of the Peck basin. The locations of wells and outcrops involved in the accompanying table are given, also the line of the section *AA*, shown in Fig. 3.

ice, it is evident that the glacial lake must have been larger than now after most of these sources have been cut off. Indeed, there is a question as to whether the basin of Devils Lake was large enough to confine all this water. If it be assumed that the amount of water supplied to the basin by ground water was balanced by loss due to seepage into the débris at either end of the lake, and that the precipitation on the surface of the lake and on the lakeward

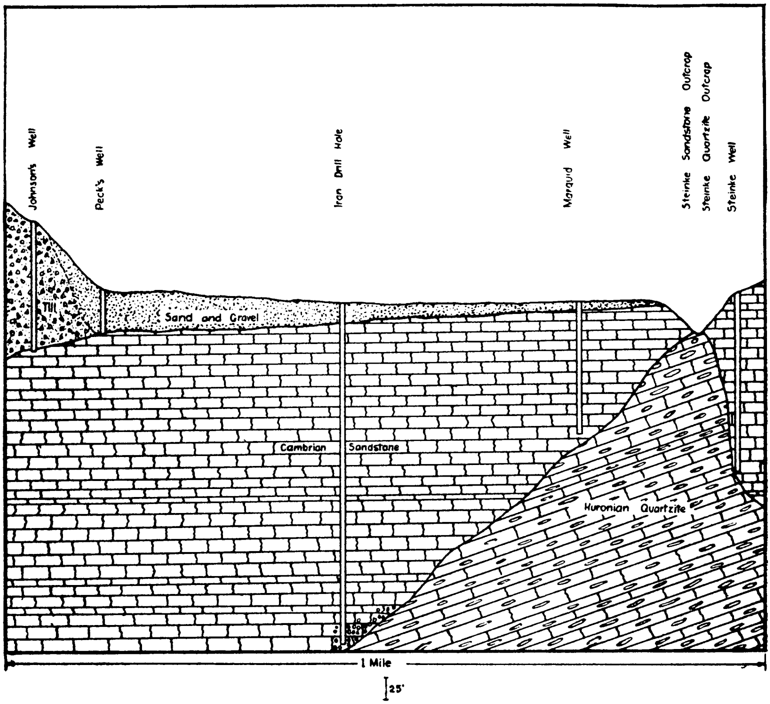


FIG. 3.—Section along line *AA*, Fig. 2, showing surficial and underground conditions in the Peck basin.

slopes was balanced by evaporation, the glacial water is still unaccounted for.

Careful measurement of the terminal moraine from the northwest edge of the Devils Lake basin, through all its curves to the crest of the Devils Nose southeast of the lake, shows that water drained into Devils Lake from 11.6 miles of ice edge. To get some conception of the amount of water which this front of ice contributed, let us suppose that the ice edge tributary to the lake had an average thickness of 100 feet (probably less than the actual thickness) for the first mile back from its edge. To estimate the total annual water supply from the ice, it is necessary to make reasonable supposition as to the amount of annual melting measured in a horizontal line normal to the front of the ice. The ice front may be considered to have been essentially stationary, and the amount of ice melted can be measured by the rate of glacial motion in the marginal portions of the ice. Chamberlin and Salisbury[1] estimate that the ice in the Greenland glacier moves something less than a foot a week near its edge. Suppose that the glacier which affected Devils Lake moved 6 inches a week or 26 feet a year. If, then, it be assumed that a volume of ice 11.6 miles long measured along the edge of the glacier, 100 feet thick measured vertically, and 26 feet wide measured normally to the ice front, melted each year and ran into Devils Lake, there would be an annual total of about 1½ *billion* cubic feet. The decreased volume due to change from ice to water may be neglected in a computation where there are so many assumptions and where all figures have been reduced to a minimum for safety.

To estimate the capacity of the basin of Devils Lake during the occupancy of the ice, it is necessary to have its length, width, and depth. Measured from moraine to moraine around the curve of the gap, the basin is almost exactly 2 miles long. The average width from end to end and from lake level to lowest point in the rim of the basin is approximately ½ mile. The depth of the glacial lake may be found by subtracting the altitude of the present lake bottom from the altitude of the lowest point in the rim of the basin, neglecting the glacial débris below the bottom of the lake, which would have displaced the water as it was deposited. Computed in this way, the maximum depth of the glacial lake was 270 feet. Multiplying the depth, width, and length, the capacity of the glacial basin was about 7½ *billion* cubic feet.

According to these figures the water from the glacier would have filled the basin of Devils Lake to overflowing in about five years. If the rate of advance of the ice was greater than assumed above

[1] T. C. Chamberlin and R. D. Salisbury, *Geology*, I, 261.

or if the ice was thicker, and both postulates are reasonable, the time required to fill the basin would have been less.

The foregoing figures may be roughly checked by an estimate of the amount of material deposited by the glacial waters. The 6 miles of ice edge which drained into Steinke Lake furnished water enough to deposit over $2\frac{1}{2}$ *billion* cubic feet *of dêbris;* in the Peck basin water running from $\frac{1}{2}$ mile of ice front deposited at least 142 million cubic feet *of dêbris;* it therefore seems safe to assume that over 11 miles of ice edge furnished over $7\frac{1}{2}$ billion cubic feet *of water.* The Devils Lake gap between the two moraine dams contains over 2 billion cubic feet of dêbris (10,000 feet in length $\times$ 1,000 feet in width $\times$ 283 feet in depth) and most of this must have come in the water from the two short stretches of glacier to the north and southeast, the water from the Steinke and Peck basins doubtless having been essentially clear.

It is not necessary to go farther to warrant the assumption that Devils Lake must have risen during the glacial epoch until it reached an outlet. On the edges of the basin there are only four low points: (1) over the terminal moraine east of the south end of the lake, (2) over or around the west edge of the moraine north of the lake, (3) at the head of the south fork of Messenger's Creek, (4) at the head of the north fork of Messenger's Creek. If the openings to the east and north be considered to have been blocked by the ice, as they doubtless were during the glacial occupancy, the lowest outlet available was between the head of the north fork of Messenger's Creek and the head of a valley tributary to the east fork of Skillett's Creek, where the altitude is between 1,180 and 1,200 feet A.T.

Salisbury and Atwood[1] found evidence that the glacial lake stood 90 feet higher than the present lake, by finding erratic, iceberg-floated bowlders in the talus on the west bluff of the lake at altitudes of 1,050 feet. Theorizing that the lake must have stood even higher than this, that it must have had an outlet, and that icebergs would float toward, and strand in, such an outlet, the writer has made

[1] R. D. Salisbury and W. W. Atwood, *Bull. No. 5, Wis. Geol. and Nat. Hist. Surv.*, p. 133.

careful search for erratic bowlders in the valleys of the north and south forks of Messenger's Creek. An hour's search revealed 103 such bowlders in the valley of the north fork, and an equal time in the valley of the south fork failed to discover one. The highest igneous rock bowlder in the north fork is at 1,162 feet, 202 feet above present lake-level, and only 28 feet lower than the divide across which the lake-water must have drained. Glacial cobbles occur within 16 vertical feet of the divide, and one diabase cobble was found on the west slope of the divide in the drainage of Skillett's Creek.

It is concluded, therefore, that during the Wisconsin epoch the waters of Devils Lake stood against the glacier at the north end, formed a bay up the valley to the northeast about as far as the north-south road in the Peck flat, reached to about the level of Elephant's Rock on the east bluff, stood against the ice at the southeast extremity of the basin, extended to within a short distance of the head of the south fork of Messenger's Creek, and spilled over the divide at the head of the north fork of Messenger's Creek, as shown in Fig. 1 and Fig. 4. Through this outlet the water flowed west into a larger lake, known as the Upper Baraboo Lake, now extinct.

THE POST-GLACIAL LAKE

As the edge of the glacier receded during the closing stages of the Wisconsin glacial epoch, the high level of the lake and its westward-flowing outlet may have been maintained for a time, but when a connection was established between Devils Lake and a lake which came into existence in the Baraboo valley, and whose surface stood at a lower level, the waters of Devils Lake were lowered to the lowest point in the morainic dams. The lowest point on the surface of either moraine was a little east of the middle of the gap at the north end of the lake, along the site of the railroad and wagon road from the lake to Baraboo. The original level of this outlet is not known, because it has now been cut almost to lake-level, but the edges of the outlet gap on the surface of the moraine at either side are at about 1,020 feet, or 60 feet above present lake-level. This is approximately the level of the surface of Devils Lake after the retreat of the ice, and before the outlet had been lowered appreciably.

From the 1,020 foot level (60 feet above the present lake) the lake surface probably was brought down rapidly by the lowering of its outlet. The stream flowing north across the moraine cut its

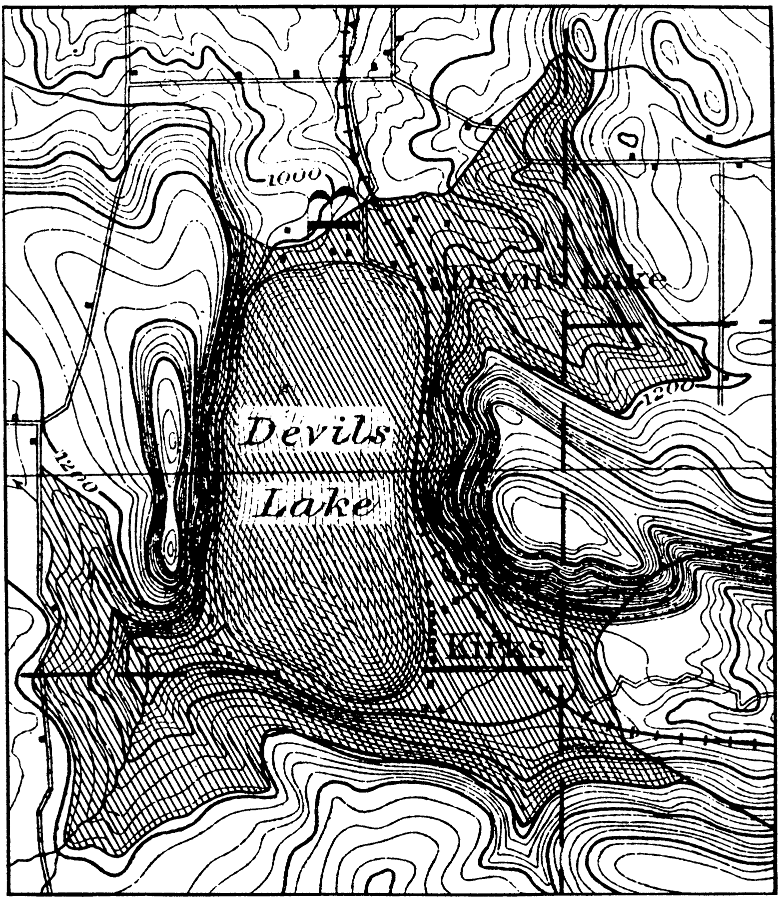


FIG. 4.—A map showing the shape and size of Devils Lake during the occupancy of the ice. The shaded area shows the lake surface. The arrow near the left margin designates the outlet. Scale: $1\frac{5}{8}$ inches equal 1 mile.

way downward in the glacial till, removing the fine material, but leaving the bowlders on its bed, lowering the lake surface from 1,020 to about 970 feet.

The lake surface apparently stood at this level (970 feet) for a time, perhaps because the outlet had made a resistant bed for itself by the accumulation of bowlders on its bottom. The evidence of this stage is a well-defined beach or barrier ridge of sand across the north end of the lake, whose crest is 8–10 feet above the lake and which confines a low, peaty area between it and the moraine. This low area back of the ridge was clearly once a lagoon. The ridge has been so strengthened artificially that it is impossible to tell whether or not it was originally broken at the old outlet, but water which could reach the top of the ridge could today flow north through the old outlet to the Baraboo River.

During this second stage of the lake it is believed still to have been receiving water from the Peck and Steinke basins (though the lakes of these names were extinct) and from a later post-Glacial lake northeast of the Steinke flat, which has become known locally as Shubring Lake. Shubring Lake occupied what is now a flat area, 1 mile by $\frac{1}{3}$ mile in extent, 4 miles northeast of Devils Lake, and just across the terminal moraine from the Steinke flat in the area of ground moraine. The Shubring flat is bordered on the north, west, and south by the inner edge of the terminal moraine and on the east by a drift-covered hill of quartzite. The slopes toward the flat are almost covered in a narrow belt parallel with the edges of the flat by thousands of bowlders which almost form a wall around the old lake bottom and which were concentrated on the shores of the shallow lake by "ice push." This lake was formed as the edge of the ice retreated, leaving an inclosed basin. During the first stages of recession of the ice, the lake received glacial waters, and after the ice had left the confines of the basin precipitation formed the source of supply. The line of outlet of the lake is plainly seen as a flat-bottomed, bowlder-strewn, linear depression interrupting the course of the terminal moraine from the southwest end of the Shubring flat to the Steinke flat south of it, and now used by Mr. Shubring as a roadway across the terminal moraine. The bottom of the valley which was the site of the outlet and the bowlder wall around the lake flat are at the same altitude (hand-level measurement), and not more than 2 feet above the level of the flat. The original depth of the lake is unknown, no records of the depth of the lacustrine fill being available.

It is clear from a study of the post-Glacial drainage conditions east of Devils Lake that the water from Shubring Lake and the Steinke Basin continued to drain into Devils Lake by way of Peck flat for a time at least after the withdrawal of the edge of the ice. These conditions must have persisted until a tributary of the Baraboo River had time to work headward up through the ground moraine on the slope of the South Range and through the terminal

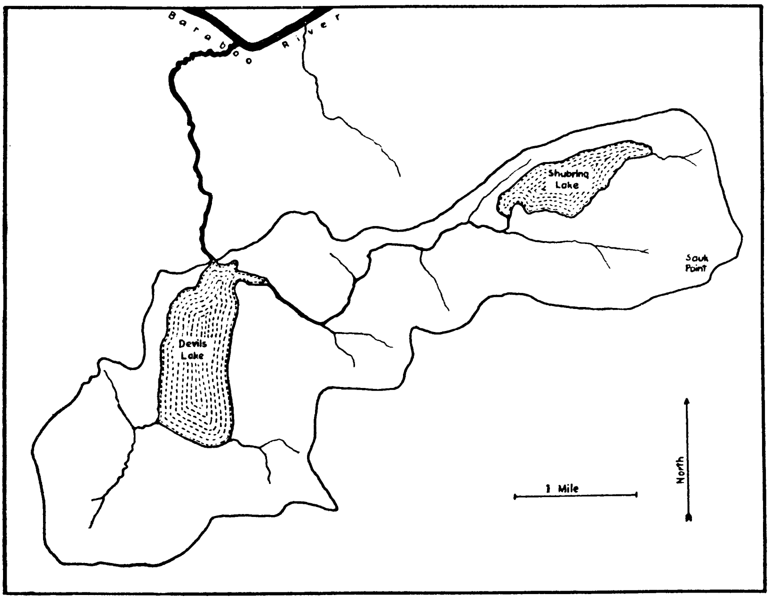


FIG. 5.—Sketch map showing the conditions of drainage around Devils Lake during the first and second stages in the post-Glacial history of the lake. The endless line marks the boundaries of the drainage basin of the lake during these stages.

moraine, to tap the Shubring and Steinke basins and divert their drainage to the north, inaugurating present conditions. The establishment of present drainage would require at least a time commensurate with the time involved in the lowering of the outlet of Devils Lake to the 970-foot level.

So long as Devils Lake had an outlet to the north, that is, until the 970-foot stage was reached, the boundaries of its basin must have been somewhat as shown in Fig. 5.

There remains but one step in the pre-human history of Devils Lake. Its outlet to the north has been abandoned. The reasons for the sinking of the surface of the lake below the level of the outlet may be several. With the gradual establishment of drainage in the ground moraine of the Baraboo valley, a tributary to the Baraboo River worked its way headward up the drift-covered slope of the South Range and through the terminal moraine into the northern

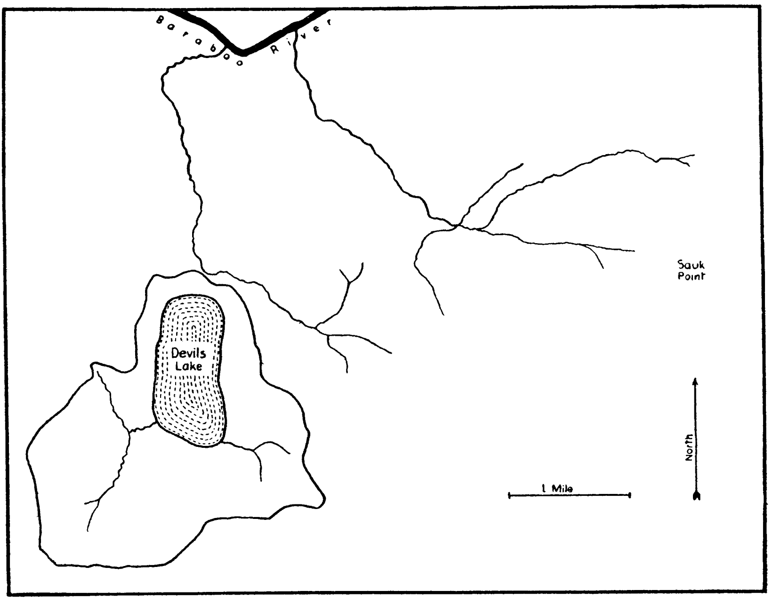


FIG. 6.—Sketch map showing the conditions of drainage around Devils Lake after the diversion of water from the Steinke and Shubring basins and the abandonment of the northward outlet. The endless line marks the boundaries of the drainage basin of Devils Lake.

portion of the Steinke flat, diverting the drainage from the east and northeast, which up to this time had gone to Devils Lake, to Baraboo River. Working rapidly in the non-resistant material of the high Steinke surface, the stream developed a tributary which worked back through the terminal moraine, tapping the Shubring basin west of its original outlet. This diversion of drainage resulted in a considerable decrease in the supply of water for Devils Lake (compare Figs. 5 and 6) and doubtless helped to cause the lake surface to sink below the level of its outlet. Conceivably also the advance of the post-Glacial epoch was attended by increasing temperature and increasing evaporation and by decreasing precipitation, so that more water was lost by evaporation than was supplied by precipitation. And perhaps the time came when underground lines of drainage were established in the gravel and sand of the drift, through which enough water was carried from the lake to cause its surface to subside. Doubtless all these factors and possibly others contributed to the lowering of the surface of the lake and the abandonment of its outlet.

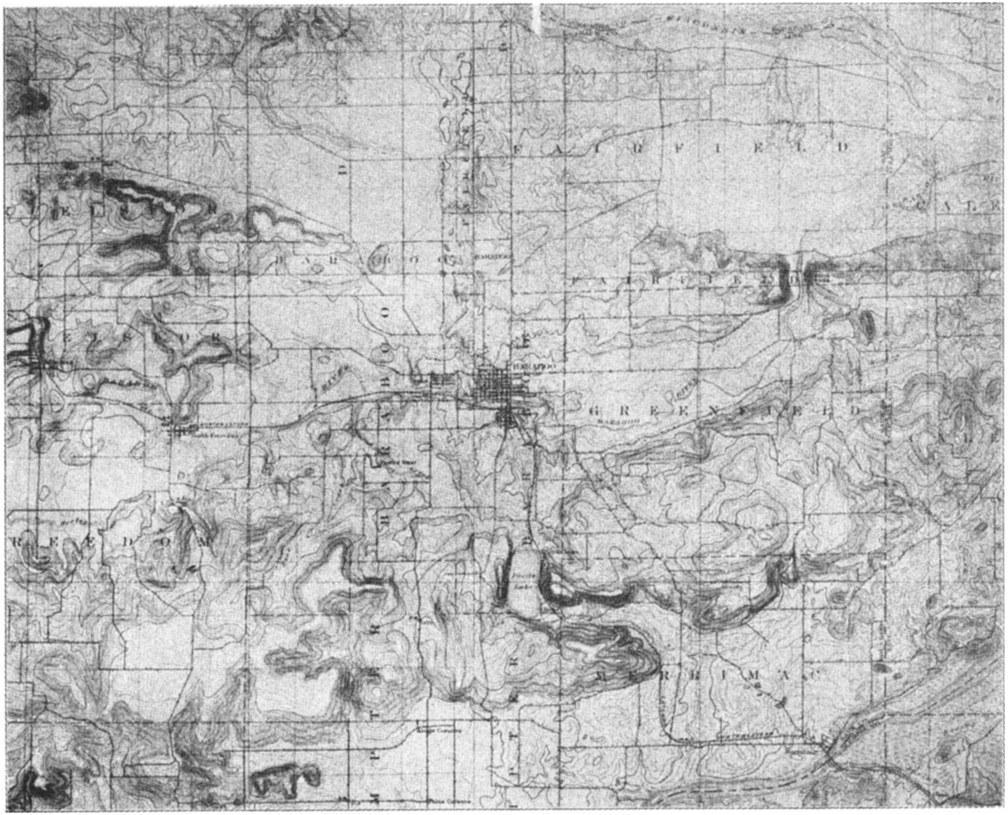
With the abandonment of the outlet, the stream from the Peck basin, which had flowed into the lake or into its outlet, chose the easier of two possible routes, avoiding the lake and flowing down the valley of the old outlet to Baraboo River. A few years ago, in order to prevent floods in its lower course, this stream was diverted again to Devils Lake by the building of a dam and the digging of a shallow ditch connecting the stream with the lake. Today the stream flows into Baraboo River or into Devils Lake, according as the temporary dam is located in the stream channel or in the artificial ditch.

The lake of today has a maximum depth of only about 40 feet, covers an area of only a little more than ½ square mile, and is without an outlet. Its drainage basin at present is shown in Fig. 6.

SUMMARY

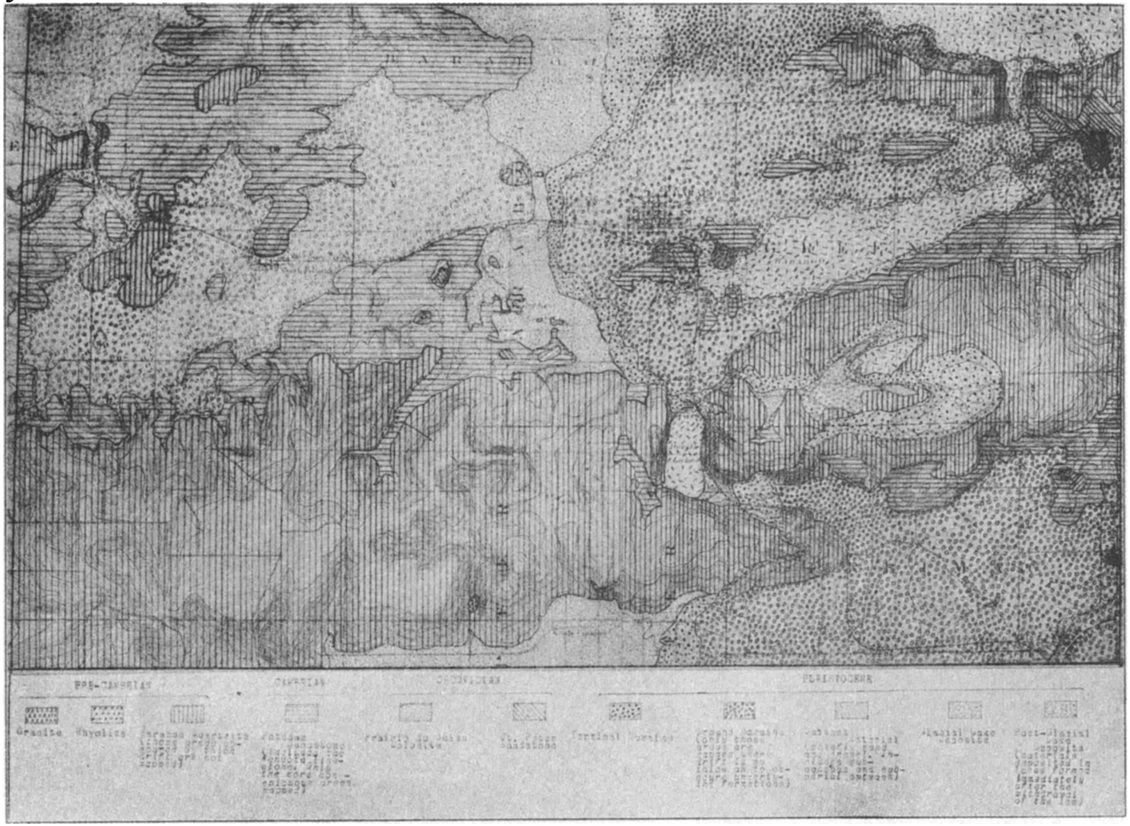
Devils Lake is seen to have had a long and complicated history. (1) Pre-Cambrian rock formations were deposited and folded. (2) Across the edges of the beds a peneplain probably was formed, over which a large stream meandered. (3) An uplift seems to have occurred and the stream intrenched itself, making a deep, curved gorge through a ridge of quartzite. (4) An early Paleozoic sea advanced over a surface of high relief and great irregularity, partially, but not completely, filling the pre-Cambrian gorge with sediments. (5) This sea withdrew at the end of the Prairie du Chien epoch, leaving a sag where the old gorge had been. (6) Conditions favoring deposition in the sea, and perhaps deposition by wind temporarily and locally, were renewed and deposition continued

until the gap was entirely filled and the pre-Paleozoic topography was buried deeply. (7) The seas finally withdrew, stream courses were developed and superimposed upon the old topography and structure, and a peneplain was developed, probably in late Tertiary time. (8) This peneplain was uplifted about 200 feet, and a second partial peneplain was developed. During this erosion cycle the Wisconsin River adjusted itself in the old gorge, and a valley about 300 feet deep was formed. (9) Another uplift to an amount of about 600 feet resulted in renewed erosion and the deepening of the gorge from 300 feet to 900 feet or more. (10) In the northern portion of the renewed gorge so formed, an ice barrier lake was formed by the edge of the Wisconsin glacier blocking the valley at two points. This lake received much glacial water, covered an area twice as large as does the present lake, was at least 270 feet deep, and had an outlet at 1,190 feet A.T., which drained northwestward. (11) With the recession of the ice, the surface of the lake dropped to about 1,020 feet and then to 970 feet, as an outlet to the north was established, and lowered through the terminal moraine dam. (12) Owing to a diversion of drainage in the Steinke and Shubring basins, decreasing the intake, and perhaps owing to changes in climate and the establishment of underground channels, the surface of Devils Lake fell from 970 to 960 feet, and the outlet was abandoned.



MAP SHOWING THE TOPOGRAPHIC SETTING OF DEVILS LAKE

Taken from the Baraboo, Briggsville, Dells, and Denzer sheets of the United States Geological Survey



Geologic Map of the Vicinity of Devils Lake