Correspondence re: International Geological Conference - 16th session - 1. 1931-1933

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CABLE ADDRESS
INTERGEOL WASHINGTON

June 11, 1931.

Messrs. E.F. Bean and F.T. Thwaites:

Dear friends:

Your letters with accompanying manuscript for the guidebook have been received, and I am proceeding with the preparation as rapidly as possible. Thank you very much for this material. I am taking the liberty of revising and shortening it somewhat. As soon as I receive Kay's and Leighton's material and get it all in shape, I expect to leave for the West.

You will probably have a chance to see the whole manuscript in the fall, if not sooner.

Very truly yours,

W. C. Alden

WCA-PFZ

Geologist.

June 2, 1931

Dr. W. C. Alden,
U. S. Geological Survey,
Washington, D. C.

Dear Doctor Alden:

I have delayed answering yours of May 2 and May 26 until I had finished the manuscript of my part of the guide book. In doing this I was confronted with two major difficulties. First, the long time until the Congress makes it inevitable that road conditions will change; there will almost certainly be some parts of the proposed route closed for paving in 1933. Second, it is impossible without a trial run to give accurate distances. The roads were once provided with mileposts but these have long since been rendered obsolete by relocations.

With these facts in mind I did the best I could. Mr. Bean agreed with me that a short time before the excursion one or both of us will make a trial run over the route calling on highway officials en route to inform us of intended detours. We will then log accurate distances and see just what state exposures are in. We will also make a schedule of time trusting that it can be enforced. To cut down time spent in photography we plan to get up a book of photographs taken on this trial run and at other times and to let members order what copies they desire. Also we will prepare a mimeographed route log with up to the minute information. This will relieve the printed guide of much which would unavoidably be out of date in 1933.

With the above plans in mind I gave up contributing any maps to the printed guide book. I may in the meantime get a chance to investigate the drumlins east of Fond du Lac and the margin of the Late Wisconsin in Waushara County. Leverett's map is all right although I doubt much of it in northern Wisconsin. However, I am sending enclosed two photgraphs taken at the Forest Bed which you might like to use(either or both).

The changes in the manuscript meet my ideas. I have no suggestions to make on either bibliography or illustrations. The Outline of Glacial Geology is not printed and the present edition is exhausted. I hope to revise it and get it out for more general circulation this summer (provided I do no get a job).

Mr. Bean is forwarding the manuscrip along with his, also a highway map showing the proposed route. We had to make some changes, notably cutting out the visit to the Beaver Dam drumlins. That area has no topography and the road crosses in such a way as to give a poor idea; highway 30 is much better, both of us think.

We have no large reserve supply of your maps. Personally I have only enough to just carry my classes. We have made no detaile route maps since an automobile route is subject to change as explained above.

Very truly yours,

Lecturer in Geology

INTERNATIONAL GEOLOGICAL CONGRESS EXCURSION, 1933

Summary of route - subject to change on account of road conditions. Mimeographed guide to be prepared from trial run just before the excursion

Night at Prairie du Chien
U. S. 18 to Bridgeport, jct with Wis. 60; Wis. 60 to Boscobel; Wis. 27 to Fennimore; U. S. 18 to Verona; C.H."M" to Middleton Junction; C.H."S" to Pine Bluff; C.H."P" to Cross Plains; Wis. 11 to Middleton; U.S. 12 to Madison; drive through U.W. grounds.
Lunch at Dodgeville; night at Madison
Estimated distance 130 miles

U. S. 12 to jct. Wis. 159; Wis. 159 to jct. Wis. 123; Wis. 123 and town road to top of West Bluff (weather permitting); Wis. 123 to jct. U. S. 12 at Baraboo; U. S. 12 to Wisconsin Dells; Wis. 13 to Coldwater Canyon; backtrack to Wisconsin Dells; U. S. 16 to Portage; Wis. 33 and 68 to Waupun; U. S. 151 to Fond du Lac; Wis. 23 to Plymouth with short detour on old route to see drumlins.
Lunch at Wisconsin Dells; supper at Fond du Lac.
Estimated distance 155 miles; this is the longest day, but this cannot be avoided unless either some of the stops near Prairie du Chien or the visit to Madison is omitted. The long trip east from Wisconsin Dells shows little of interest.

North on Wis. 57 to Elkhart Lake; east on C.H."A" to jct. with U. S. 141; north on U. S. 141 to Manitowoc; Wis. 17 to Two Creeks; backtrack to Manitowoc; Wis. 31 to jct. Wis. 32; Wis. 32 to Elkhart Lake; C.H."A" and C.H. "S" to Kewaskum; Wis. 55 to West Bend
Lunch at Two Rivers
Estimated distance 125 miles

West on Wis. 33 to jct. with C.H. "J"; south on "J" to Slinger; west on Wis. 60 to jct. with C.H. "K"; south on "K" to North Lake; south on Wis. 83 to jct. with U. S. 18; west on 18 to jct. with Wis. 67; north on 67 to jct. with Wis. 30; west on 30 to jct. with C.H."D"; south on "D" to U. S. 18; east on 18 to jct. with Wis. 90; south on 90 to jct. with Wis. 59; 59 to Eagle; south on Wis. 67 to jct. C.H."N"; south on "N" to jct. with C.H. "K"; west on "K" to jct. with U. S. 12; west on 12 to jct. with C.H."P"; south on "P" to C.H."A"; west on "A" to Richmond; south on Wis. 89 to town road northwest of Walworth; town road to Wis. 36; Wis. 36 to Walworth.
Lunch at Delafield
Estimated distance 125 miles
Choice of Walworth or Delavan for night.

DESCRIPTION OF ROUTE
Continued by F. T. T.

Going east from Wisconsin Dells the terminal moraine of the Green Bay Lobe of the Middle Wisconsin substage[1] is crossed. As the ice fell back from this

[1] Alden, W. C., The Quaternary geology of southeastern Wisconsin: U. S. Geol. Survey Prof. Paper 106, p. 220, 1916.

moraine, Lake Wisconsin extended eastward with unchanged outlet and level until the dam was broken by an outlet around the east end of the Baraboo Range. When this happened, the waters fell to a level determined by the highest moraine which crosses the course of the present river south of the Range. The level of Lake Wisconsin then fell to that fixed by the sandstone ridge at the Dells east of which the waters escaped through a low place in the moraine to join the new lake which is known as Early Glacial Lake Oshkosh. Several halts of the retreating ice front are marked by deltaic moraines deposited in this lake; when the cuts on the highway were fresh, they showed foreset bedding dipping west[2]. The early high levels of Glacial Lake Oshkosh

[2] Idem, p. 261.

left no definite beaches near Portage (pop.6,308;elev. 811), for the open water areas in that locality were small because of islands and masses of stagnant ice. Some of the latter seem to have persisted until after the outlet had been cut down from approximately 875 feet to about 825 feet, for at Pardeeville an outwash train enters the lake bed at the last elevation. This plain does not head in a moraine but instead in a large marsh which must have then been filled with ice. After the retreating border of the Middle Wisconsin ice cleared the Niagara escarpment northeast of Lake Winnebago, the level of Early Glacial Lake Oshkosh fell so that the Portage outlet was not used. When the readvance which is called the Late Wisconsin

or Red Drift occurred, this outlet was blocked and the waters again occupied the Portage col at elevation about 825. Later, during the recession of the Late Wisconsin ice, the col was eroded to its present level, about 796 A.T. Little can be seen of the outlet from the highway, but it should be noted that the Wisconsin River persisted in its course from the Dells to the lower or preglacial part of its valley south of the Baraboo Range although it is now higher at Portage than the Fox River which flows into Lake Michigan. A levee prevents flood waters from entering the Fox.

From Pardeeville (pop. 873, elev. 810) to the vicinity of Fox Lake the route lies over ground moraine. An esker is passed just west of Cambria (pop. 671, elev. 861). West of Fox Lake (pop. 901, elev. 885) the Green Lake Moraine, a recessional of the Middle Wisconsin, is crossed. A few low drumlins are seen near this point[3].

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[3] Idem, p. 296.

Northeast of Waupun (pop. 5,768, elev. 888) the Waupun Moraine is crossed. It manifests itself as numerous 30 to 50 foot knolls of very stony till in which large blocks of the local Galena dolomite make up almost the entire mass[4]. At Lamartine (not incorp.ated) the Galena outcrops in the creek bed.

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[4] Idem, p. 298.

About two miles east of this point red lake clay occurs and soon the road ascends a low ridge with a few slight kettles. This was mapped by Alden[5]

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[5] Idem, p. 319.

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as the terminal moraine of the Red or Late Wisconsin substage. Studies elsewhere, however, seem to indicate that this substage at its maximum did not last long enough for the formation of a true endmoraine. It is probable

that this ridge has a core of gray or Middle Wisconsin drift.

Fond du Lac (pop. 26,449, elev. of Lake Winnebago 747) is situated in the bed of Later Glacial Lake Oshkosh, formerly known as Glacial Lake Jean Nicollet[6]. Beaches occur from 825 down to 795 feet but are not conspicuous at all points, particularly on the west shores. This phenomenon is explained by the winds which blew off the cold glacier and forced pack ice against that side of the lake.

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6 Alden, W. C., The Quaternary geology of southeastern Wisconsin: U. S. Geol. Survey Prof. Paper 106, pp. 324-325, 1916.

Two miles east of Fond du Lac a beach at elevation 810 demonstrates the presence of northerly winds as it is a spit built out from the east shore. Extended studies of beaches of Lake Oshkosh by Thwaites have shown similar results. At this place the lake gravels are interbedded with and highly stained by red clay. Such deposits as this have little economic importance on account of the clay stain which cannot easily be removed by washing to permit use in concrete aggregate. Moreover, such beach deposits are almost universally very small and thin.

The eastern shore of Later Glacial Lake Oshkosh lies along the foot of the Niagara dolomite escarpment where that resistant formation lies above the weak Richmond shale. As pointed out by Martin, the outline of the Niagara escarpment in eastern Wisconsin contrasts sharply with that of eastern Iowa and northwestern Illinois in being decidedly more even and smooth. There are very few outliers of the Niagara in Wisconsin. Martin[7] ascribes these facts to glacial

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7 Martin, Lawrence, The physical geography of Wisconsin: Wisconsin Geol. and Nat. Hist. Survey, Bull. 36, pp. 230-235, 1916.

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erosion. As the shale below the jointed dolomite ledges must have furnished

a very slippery foundation, many large masses of rock were removed and the escarpment straightened to its present form. In the west and for that matter farther south glaciation was less vigorous and the direction of movement less well adapted to erosion. Other escarpments without shale were not so highly altered by glaciation.

Ascending the escarpment we pass the border of the Late Wisconsin Red till. As this formation thins out gradually, at the top of the grade weathering has largely destroyed its identity. The morainic topography is clearly due to deposits of Middle Wisconsin age which were later veneered with Red till.

East of the escarpment the route passes through a remarkable group of drumlins which are somewhat shorter and rounder than is common in Wisconsin. The most peculiar phenomenon is the variety of directions of the long axes; these fall into two groups: (a) west to southwest, and (b) south to south-southwest. Alden[8] regarded these drumlins as due to erosion of terminal

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[8] Alden, W. C., The Quaternary geology of southeastern Wisconsin: U. S. Geol. Survey Prof. Paper 106, p. 250, 1916.

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moraines by a change in ice direction and cited crossing striae as evidence. Thwaites suggests an alternative explanation. During the Early Wisconsin substage the source of ice was farther east than later. and led to the very large Lake Michigan Lobe of Illinois. The extension of this lobe in Wisconsin is unknown north of the place near the south border of the state where Marengo Ridge is buried by the Darien (West Chicago) Moraine. It seems fair to suggest that the southwesterly trending drumlins east of Fond du Lac were formed by Early Wisconsin ice whose terminal lay west of the Niagara escarpment. If this is correct, the cores of these drumlins should contain no Galena dolomite pebbles or boulders. During Middle Wisconsin time the ice entered the Green Bay-Lake Winnebago lowland more directly from the north and spread out over the Niagara

escarpment to the east, reshaped the drumlins, and deposited over them drift which carries Galena dolomite fragments. A few drumlins seem to have escaped much alteration; others have had new tails built which trend south; some have two distinct tails; still others conform exactly to the later direction of movement. A few drumlins have the stoss side more gentle than the lee and suggest that they were caused by erosion of the older hills, but most of them are typical in outline. Weakness of glacial erosion and origin of drumlins by a combination of shoving plus accretion are conclusions from the facts known at the time of writing.

Leaving the drumlin area the highway passes over ground moraine liberally mixed with small discontinuous patches of recessional moraines formed by retreat of the east margin of the Middle Wisconsin Green Bay Lobe. At Greenbush (not incorp.) the famous Interlobate Moraine is entered. Here the hills consist almost entirely of gravel, for meltwaters were closely confined between the two lobes and reworked whatever till was deposited. In this area it is not safe to conclude that till is present because the surface is overlain with boulders, for many large ice-rafted stones occur in the assorted materials. The topography of the Interlobate is rugged in the extreme; knobs, ridges, and mounds with a relief of over 150 feet are interspersed with enclosed kettles. In many places the slopes are that of the angle of repose of wet gravel, over 30 degrees. Much of the Interlobate or Kettle Range is wooded. Although it is the highest land between Lake Michigan and the Fox-Winnebago lowland, it forms a water parting in but few places, for there are many breaks through which streams pass. When the margins of the two lobes stood close together, assortment of the material was not good and coarse, ill-assorted bouldery gravels were formed in the reentrant. When included ice masses and the supporting ice walls melted, irregular ridges, knolls, and cones of gravel were left. The latter are called kames.

In a few places the conical hills may represent cones formed at the bottoms of moulins; other coarse gravels were doubtless deposited in open crevasses. When the angle widened, new lower outlets were opened for the meltwater and terraces of better sorted gravels were formed. Many ice blocks still survived buried in the sediments and later melted to form terraces of pitted outwash. The mapping by Alden did not in general attempt to separate till moraines, kames, and pitted terraces although he mapped the larger non-pitted or slightly pitted outwash deposits. Several distinct terrace and drainage channel levels with unconsumed remnants of older higher levels rising above them can be seen along the highway approaching Plymouth (pop. 3,882, elev. 845). Just west of the city a moraine, largely gravel, marks the western side of the Lake Michigan Lobe at the time of formation of the lowest terraces [9].

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[9] Alden, W. C., The Quaternary geology of southeastern Wisconsin: U. S. Geol. Survey Prof. Paper 106, pp. 304-309, 1916; Thwaites, F. T., The origin and significance of pitted outwash: Jour. Geology, vol. 34, pp. 308-319, 1926.

The highway from Plymouth to Elkhart Lake (pop. 571, elev. 946) is through terraced and pitted outwash like that seen west of Plymouth. At Elkhart we turn east through more pitted outwash and a recessional moraine of the Lake Michigan Lobe. The first Red Drift is observed just east of a school house on the south side of the highway, but there is no terminal moraine at the margin of this substage. About a mile west of Franklin (not incorp.) at the top of a steep descent to the east is a large gravel pit. Here the bright red till of the Late Wisconsin overlies kame gravels of an older Middle Wisconsin or "gray" recessional. Locally some gray till of the older glaciation occurs between the gravels and the red till. At other places the older sediments have been folded by the overriding Later Wisconsin ice.

East of Franklin the country is low nearly level ground moraine of

the Late Wisconsin. This topography is due to several factors: (a) clay tills such as the "red" drift flow when wet and form level drift plains; (b) much of the red drift overlies gray outwash plains, and (c) much of the red till overlies older lake deposits.

East of Howards Grove (not incorp.) a low ridge of red drift contains some kettles and was mapped by Alden as terminal moraine; such features may be like the moraine farther west, inheriting their topography from buried Middle Wisconsin moraines.

Turning north we recross this belt of weak moraine at St. Wendel (not incorp.). At Fisher Creek[10] pits west of the highway expose gravels under

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[10] Alden, W. C., The Quaternary geology of southeastern Wisconsin: U. S. Geol. Survey Prof. Paper 106, pp. 312,330, 1916.

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the red till. These gravels by their bedding and excellent assortment of some of the thin layers show beach origin. Although the elevation of the top of the gravels is not known, it is fair to suppose that they are part of the Glenwood beach formed in Lake Chicago during the retreat of the Middle Wisconsin ice although Alden thought that they might have been deposited in a local lake at a higher level.

From Fisher Creek to Manitowoc (pop. 22,963, elev. of Lake Michigan 581) little of interest is seen. The exact extent to which the land was submerged by the Calumet stage of Glacial Lake Chicago, 40 feet above the present, is not known on account of lack of topographic maps[11].

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[11] Idem, p. 332.

Just north of Manitowoc several gravel pits can be seen on both sides of the highway. The gravels are deltaic deposits probably made at the margin of the ice in the Glenwood stage of Lake Chicago. Lake silts and clays, much

disturbed by ice shove, overlie a large part of the deposits, but no till has been discovered. The silts and clays may have been deposited in front of the advancing Late Wisconsin ice. In places weathering of these clays has carried calcium carbonate into the gravels cementing them into conglomerate. In places beach sands and gravels, probably of Calumet age, overlie the folded beds unconformably. It is suggested that the waters of Later Glacial Lake Chicago reworked and obliterated the thin red till left on the top of the deltas.

From Manitowoc to Two Rivers (pop. 10,082) the highway runs on the beach of Lake Michigan. Sand dunes may be seen on both sides of the road.[12]

At Two Rivers the Nipissing and Algonquin (both Toleston) beaches are

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12 Goldthwait, J.W., The abandoned shore-lines of eastern Wisconsin: Wisconsin Geol. and Nat. Hist. Survey, Bull. 17, pp. 57-59, 1907.

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well shown both as cliffs and barriers. North from the city, much of which is on sandy Nipissing lake bottom, the highway passes along a ridge of red till which locally resembles a weak terminal moraine. As no trace of the Calumet beach is known north of Two Rivers, this ridge may mark the ice border at the maximum extent of that stage of Lake Chicago[13].

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13 Idem, pp. 59-61, 109-119.

The Two Creeks Forest Bed was discovered by Goldthwait[14], later explored

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14 Idem, pp. 61-62.

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to some extent by Thwaites, and last worked on in detail by Wilson[15]. The

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15 Wilson, L. R., The Two Creeks Forest Bed, Manitowoc County, Wisconsin: Unpublished thesis, University of Wisconsin, 1931.

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following section is exposed:

Algonquin

	Feet
Clay, red, and yellowish gray, varved, dolomitic, found up to about 25 feet above Lake Michigan.....	5

Late Wisconsin

Till, red, clayey, dolomitic, some wood.....	8-15
Silt, and clay, red, dolomitic, some shells.....	0.5

Interglacial

Forest Bed - peat, stumps, logs, branches, etc., local distribution.....	0.5

Glenwood

Clay, sand, and silt; clay, red, silt, gray to yellowish grey, dolomitic, top part contains organic remains.....	7-12

Middle Wisconsin

Till, clayey, gray, dolomitic.....	3

Wilson found that spruce is the only determinable wood although pollen of jackpine was discovered. He found 19 species of mosses and 7 of mollusks. Fungi, mites, beetle excavations on logs, and pollens of several upland plants were also collected. The flora and fauna indicate a colder climate than today, one like that of northern Minnesota at present.

A similar section is also exposed in the pit of the Manitowoc Portland Cement Company at Manitowoc except that no Forest Bed is present. The elevation of the clays suggests that they were deposited in the Glenwood stage of Lake Chicago.

At both places the amount of disturbance due to the Late Wisconsin ice varies widely. Locally the underlying beds seem to have been buried by lake sediments and little disturbed by glacial shove. A few feet away all the sediments below the red till are highly folded and contorted. Great boulders of silt, clay, and gravel are found in the red till. Locally masses of vegetal remains have been mingled not only with the stratified beds but even with the basal gray till.

The surface on which the forest grew undulates considerably and both north and south of the exposures disappears below lake level.

The evidence of the Forest Bed fixes the low water stage of Lake Chicago between the Glenwood and Calumet stages[16].

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16 Alden, W. C., The Quaternary geology of southeastern Wisconsin: U. S. Geol. Survey Prof. Paper 106, pp. 332-335, 1916.

West of Manitowoc a marked terminal moraine is crossed which is probably of Middle Wisconsin age veneered with red till. Cuts in another moraine farther west show a basement of gray till.

The quarry at Valders (pop. 504, elev. 812) shows the relations of the Middle and Late Wisconsin ice sheets. The hill is a reef of Niagara dolomite. The till above the rock varies from 5 to over 10 feet in thickness. At both the north and south ends of the opening gray till is found beneath the red; in the center only red till occurs. Where gray till is present, the only striae trend approximately south; but where the red till rests directly upon the rock, striae bearing about west also occur and locally obliterate the older markings. The latter demonstrate that the ice of the Late Wisconsin substage moved west, for they are best developed on the east-facing sides of the older grooves. About two miles northwest of this point Alden[17] discovered striae beneath gray

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17 Idem, pp. 317-318.

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till which he thought indicated a southeasterly movement; in the light of the information now available at Valders, it is more plausible to suppose that the movement was northwest and that the ice of the Late Wisconsin Lake Michigan Lobe extended much farther west. The thin edge of the red till of the Late Wisconsin is very difficult to trace and therefore its lobation is hard to determine. The ice which reached Valders must have crossed the upper end of Door County peninsula between Green Bay and Lake Michigan and then spread out

in the low ground west of Lake Michigan where the Green Bay Lobe could not cross the high interlobate moraine of Middle Wisconsin age.

A prominent moraine which is crossed west of Valders is mapped by Alden as a recessional of the Green Bay Lobe. It contains, however, very little, if any, Galena dolomite and it has been suggested by Thwaites that it is the interlobate of the Middle Wisconsin. Reconnaissance to the north tends to confirm this suggestion. It is not certain but that this moraine where first seen has been overridden by the Late Wisconsin, for red clay and red till are found in some of the kettle holes. Surveys by Thwaites have shown that similar overridden moraines near the border of the Red till were little altered and in many places it is difficult to prove the presence of a later drift. This phenomenon of disappearance of a thin till through weathering and erosion doubtless explains the peculiar border of the Iowan drift in Iowa, long a source of perplexity if not a reason for doubting the existence of such a drift.

The route south to Elkhart Lake passes through the same moraine. From Elkhart Lake we pass over pitted outwash terraces to Glenbeulah (pop. 284, elev. 972). Crystal Lake with its steep gravelly shores, islands, and large number of cottages is a typical kettle lake intensively developed as a summer resort.

The large commercial pit at Glenbeulah (Elkhart Moraine Sand and Gravel Company) appears to be a deltaic kame formed in the reentrant between the Green Bay and Lake Michigan lobes. From Glenbeulah to Greenbush we follow the foot of the west side of the Interlobate.

From Greenbush south to Dousman (pop. 256, elev. 868) the route lies almost wholly in the Interlobate Moraine and its associated outwash terraces[18].

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[18] Alden, W. C., The Quaternary geology of southeastern Wisconsin: U. S. Geol. Survey Prof. Paper 106, pp. 269-270, 283, 289-293, 1916.

Two very high peaks, one of which is a kame which was probably deposited in a moulin some distance from the open part of the ice reentrant, may be seen. These are Sugar Loaf or Pulforts Peak (elev. 1320) southeast of Hartford and Holy Hill (elev. 1361) which is surmounted by a Catholic church. South of North Lake where there is a large commercial gravel pit in a terrace, the Interlobate is not present for several miles until it is resumed in Lapham Hill formerly known as Government Hill (elev. 1233). Lapham was one of the early State Geologists of Wisconsin and what is now Holy Hill was formerly named Lapham Peak. When this name was superseded, it was moved to replace the meaningless name of the lower hill to the south. This break in the Interlobate is due in large part to the fact that streams fed by the melting Lake Michigan Lobe here crossed into the area just vacated by Green Bay ice. Farther south, east of Delafield, there are several abandoned stream channels[19]. That followed by

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19 Alden, W. C. The Quaternary geology of southeastern Wisconsin: U. S. Geol. Survey Prof. Paper 106, p. 291, 1916.

Wis. 30 seems to have been the latest. It carried water from a block of ice in the basin of Pewaukee Lake west across a stagnant block in Lake Nagawicka to the Bark River, a tributary of the Rock. At an earlier stage this stream must have gone south through the valley which lies just below the State Tuberculosis Sanitarium. At first this valley probably discharged south to the vicinity of Eagle, but later recession of the Green Bay ice opened an outlet to the west now followed by U.S. 18. Melting of the Lake Nagawicka ice block then diverted the headwaters of the stream to the west; and the shorter course soon entrenched itself and left the head of the Sanitarium valley hanging.

From the Interlobate of the Delafield (not incorp.) region the route takes us west into a typical drumlin landscape. The drumlins of this region[20]

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20 Idem, pp. 253-256; Alden, W. C., The drumlins of southeastern Wisconsin: U. S. Geol. Survey Bull. 273, 1905.

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trend slightly east of south, for they were deposited by the southeasterly quadrant of the Green Bay Lobe. Eskers[21] may be seen between the drumlins.

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21 Alden, W. C., The Quaternary geology of southeastern Wisconsin; U. S. Geol. Survey Prof. Paper 106, pp. 284-288, 1916.

Instances of crossing of drumlins by eskers are rare in Wisconsin; for the most part the gravel ridges are confined to the low swampy tracts between the drumlins.

As the drumlin area does not extend south within several miles of either the terminal or interlobate moraines, no more drumlins are seen beyond a point a few miles south of Rome (not incorp.) Much of the low ground along Scuppernong Creek was the site of a temporary glacial lake until an outlet was eroded through the moraines to the southwest.

From Palmyra (pop. 642, elev. 840) to Eagle (pop. 392, elev. 945) the Interlobate is recrossed. From Eagle south is a remarkable series of outwash terraces, all of them pitted, which was explained by Alden[22] as due to changes

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22 Alden, W. C., The Delavan Lobe of the Lake Michigan Glacier --: U. S. Geol. Survey Prof. Paper 34, pp. 44-49, 57-62, 1904; The Quaternary geology of southeastern Wisconsin: U. S. Geol. Survey Prof. Paper 106, pp. 267-269, 275-277, 1916.

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in drainage outlets as a result of ice recession. The highest terraces were formed when the meltwater from the Green Bay and Lake Michigan fronts escaped to the southwest to Rock River via the Turtle Creek outlet. Later terracing was due to (a) erosion of this outlet and (b) the successive uncovering of two lower outlets to the east via the Fox River of Illinois. Present day exposures indicate that many moraines shown by Alden in this region are pitted and dissected terraces of sand and gravel.

The route leads across the Elkhorn Moraine[23], a recessional of the westward

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[23] Alden, W. C., The Quaternary geology of southeastern Wisconsin: U. S. Geol. Survey Prof. Paper 106, pp. 258259, 1916.

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bulge of the Lake Michigan Lobe known as the Delavan Lobe. Where the Interlobate is recrossed on U.S. 12, its southeastern side is buried by outwash and shows that here the Green Bay ice lasted longer than did the Lake Michigan Glacier. In the abandoned railway cut the excessively stony character of the till is well shown. Much of the material was of local derivation[24].

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[24] Alden, W. C., The Delavan Lobe of the Lake Michigan Glacier --:. U. S. Geol. Survey Prof. Paper 34, pp. 36, 53-56, 1904.

At Richmond (not incorp.) the angle between the Green Bay and Lake Michigan lobes is seen where the Johnstown and Darien moraines coalesce into the Interlobate. Adjacent to this place the outwash, which is not pitted, is highly dissected by waters which escaped after the ice fronts had receded a few miles from their maximum[25].

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[25] Idem, pp. 38-39; Alden. W. C., The Quaternary geology of southeastern Wisconsin:. U. S. Geol. Survey Prof. Paper 106, pp. 235-241, 1916.

From Richmond south the route closely follows the outer edge of the Darien Moraine and crosses the Turtle Creek drainage outlet which contains a marked terrace. A pit just north of Wis. 20 was the source of coarse aggregate for the concrete paving[26].

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[26] Alden, W. C., The Delavan Lobe of the Lake Michigan Glacier --:. U. S. Geol. Survey Prof. Paper 34, pp. 33-34, 1904; The Quaternary geology of southeastern Wisconsin: U. S. Geol. Survey Prof. Paper 106, pp. 232-234, 1916.

At Darien (not incorp.) the outside of the moraine is reached. To the southwest low rolling ground moraine and low gullied drumlins of the Illinoian drift can be seen contrasting sharply with the fresh uneroded knolls of the

moraine[27].

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27 Alden, W. C., The Quaternary geology of southeastern Wisconsin: U. S. Geol. Survey Prof. Paper 106, pp. 138-140, 1916.

At Fontana (pop. 385, elev. of Lake Geneva 864) an abandoned commercial gravel pit exposes very coarse bouldery horizontally stratified gravel beneath till which is a part of the Darien Moraine. Some of the gravel has been cemented into conglomerate. The till extends only a short distance down the side of the gigantic kettle in which Lake Geneva lies. This depression is a preglacial valley. Springs and wells show that till lies beneath the gravels. The history is (a) advance of Middle Wisconsin ice depositing till, (b) recession to east of Elkhorn leaving gravels with buried ice blocks, (c) readvance to Darien Moraine before all of the larger blocks were melted, and (d) melting of ice blocks after last recession of ice leaving the basin of Lake Geneva. Alden's mapping shows that the ridge south of the lake is the main continuation of the Darien Moraine, but later studies in Illinois make this conclusion doubtful. The basin escaped filling because it was parallel to the direction of ice flow[28].

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28 Alden, W. C., The Delavan Lobe of the Lake Michigan Glacier —: U. S. Geol. Geol. Survey Prof. Paper 34, pp. 30-31, 50, 1904.

Southeast of Walworth (pop. 920, elev. 1004) the red till Marengo Ridge Moraine enters Wisconsin and is lost beneath the Darien Moraine. Their relations will be explained during the trip in Illinois[29].

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29 Idem, pp. 22-24; Alden, W. C., The Quaternary geology of southeastern Wisconsin: U. S. Geol. Survey Prof. Paper 106, pp. 182-183, 231-232, 1916.

INTERNATIONAL GEOLOGICAL CONGRESS
XVITH SESSION, U.S.A., 1932
GENERAL SECRETARY
U.S.GEOLOGICAL SURVEY, WASHINGTON, D.C.

CABLE ADDRESS
INTERGEOL WASHINGTON

May 26, 1931.

Dr. F.T. Thwaites,
University of Wisconsin,
Madison, Wis.

Dear Doctor Thwaites:

I have gone over your comments on my manuscript for the International Geological Congress guidebook and have made some minor changes in consequence. I will not go into a discussion of all these points in this note. It seems to me that I have given about enough general outline in my manuscript as revised. I have not yet received any criticisms from Dr. Leighton.

In the description as to preglacial conditions, it seems to me there should be about such a statement regarding the supposed peneplains as I have given, in view of Trowbridge's interpretations and inasmuch as Kay and Apfel have put so much concerning them into their recent paper in Iowa Geological Survey Vol.34, "The pre-Illinoian Pleistocene geology of Iowa." I do not understand that the Nebraskan drift in erosion valleys cited by Leverett is wholly from wells but partly from exposures, and should be taken into consideration. I understand from your Outline of Glacial Geology that you think it well established that some of the rock floors of the valleys have been lowered as much as 200 feet since Nebraskan time. By the way, perhaps your mimeographed Outline of Glacial Geology should be cited in the bibliography. I inferred, however, that it was not available for sale or general distribution.

Very truly yours,

W. C. Alden

Geologist.

May 26, 1931.

Drs. Kay, Leighton, and Thwaites:

Dear friends:

Relative to the International Geological Congress guidebook for the glacial excursion (1933), I am sending herewith:

A. - List of material available here for illustrations. It is not certain that so many will be wanted. Suggestions are invited for eliminations or for the substitution of other material which you will send in soon, and which can be easily prepared for publication. This list does not include the route maps which you are expected to submit as soon as you can with your itinerary notes. In the "explanation" of his map of the drift sheets, Dr. Leverett wishes the Wisconsin drift blocks for "substages" 5 and 4 to be grouped together as "Late Wisconsin drift," that for "substage" 3 to be labeled "Middle Wisconsin drift," and those for "substages 2 and 1 to be grouped together as "Early Wisconsin drift."

B. - A selected bibliography. Suggestions for eliminations and substitutions are invited. This list is probably long enough. References will probably be made by authors' names and numbers, as indicated in the following:

C. - New copies of some pages of my general introduction which have been revised somewhat after consideration of suggestions made by Leverett, Kay, and Thwaites. The quotation from Leverett on "Relative length of Pleistocene glacial and interglacial stages" on page 13 will probably be omitted.

Very truly yours,

W. C. Alden

Inclosure.
WCA-PFZ

ILLUSTRATIONS

Maps and drawings

I Map of drift sheets in north-central United States, showing subdivisions of the Wisconsin drift. Cross(es) indicate outlying erratic boulders and patches of till. (Frank Leverett, 1931.)
(Use fig.5, Prof. Paper 154-A with explanation changed to show early, middle, and late Wisconsin drift as indicated.)

II Map showing isobases of glacial Lake Algonquin at its highest stage and isobases of glacial Lake Iroquois (in Lake Ontario basin) as represented by Goldthwait. The figures above the isobases indicate altitude above the horizontal or unaffected part of the beach south of the hinge line; the figures in parentheses below the isobases and the scattered figures elsewhere indicate altitude above sea level. (Frank Leverett, 1929.)
(Use fig.9, Prof. Paper 154-A, p.65.)

III Wisconsin River, low terrace and drift-covered, high terrace near Bridgeport, Wis. (Gen. G.K. Warren's Rept., 1876.)
(See Pl.XIX-A, Prof. Paper 106.)

Photographs

1. Illinoian till plain dissected and later loess-mantled. Rock Island County, Ill. (Alden neg. 763-A.)
(See Pl.XII, p. 165, Iowa Geol. Survey, vol.26.)

2. Compared topographies of uneroded Iowan drift plain (A) and Kansan drift plain in eastern Iowa, maturely dissected and loess-mantled (B). (Alden neg.800-A.)
(See Pl.V, p. 69, Iowa Geol. Survey, vol.26.)

3. Glacial drift and loess exposed near Delmar Junction in eastern Iowa. A, Nebraskan till; B, Aftonian gravel; C, Kansan till; D, Peorian loess. (Use Alden neg. 841-A.)
(See Pl.II, Galena-Elizabeth folio 200.)

4. Glacial drift and loess exposed northeast of Des Moines, Ia. A, Kansan till; B, Kansan gumbotil; C, Peorian loess; D, late Wisconsin till. (Use middle part of Alden ngg. 788-A.)
(See Pl.XI, Iowa Geol. Survey, vol.26, or fig.6 on back of Camp Dodge, Ia., topographic map.)

5. Topography in driftless area of southwestern Wisconsin. (Alden neg.315.)
(See Pl.V-A, Prof. Paper 106.)

6. Dells of Wisconsin River in Cambrian sandstone, Kilbourn, Wis. Photo by A.D. Hole.

7. Outwash sand and gravel of Green Bay glacier, Janesville, Wis. (Alden neg.178.)
(See Pl.XXIV-B, Prof. Paper 106.)

8. Morainal topography, Manitowoc County, Wis. (Alden neg. 458.)

9. Drumlin east of Jefferson, Wis., longitudinal profile. (Alden neg. 52.)
(See Pl.XXV-A, Prof. Paper 106.)

10. Drumlin east of Jefferson, Wis., transverse profile. (Alden neg. 48.)

11. Esker near Francis Creek, Manitowoc County, Wis. (Alden neg.455.)

12. Wave-cut terrace formed at Nipissing stage of the Great Lakes, north of Milwaukee, Wis. (Alden neg. 109.)
(See Pl.XXXIX, Prof. Paper 106.)

13 general view of Forest Bed Trip 235
246

14 Slumps in " "

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Quaternary period in the Mississippi River Basin

By
Wm. C. Alden,
United States Geological Survey

INTRODUCTION

Classification in use at present by the United States Geological Survey.

Quaternary period

Recent epoch

Pleistocene epoch

9. Wisconsin stage of glaciation.
8. Peorian stage of deglaciation.
7. Iowan stage of glaciation.*
6. Sangamon stage of deglaciation.
5. Illinoian stage of glaciation.
4. Yarmouth stage of deglaciation.
3. Kansan stage of glaciation.
2. Aftonian stage of deglaciation.
1. Nebraskan stage of glaciation.

In the studies leading to this classification, numerous geologists took part; among the most prominent of whom were T.C. Chamberlin, Samuel Calvin, and Frank Leverett. Leverett, Kay, and Leighton have proposed certain changes in the general classification of the North American Pleistocene deposits as noted in the following pages. Kay has urged that the several gumbotils and the interglacial

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* By some geologists the Iowan is correlated with the Illinoian glaciation and by others as earliest Wisconsin. See Leverett (25); Kay (16); Leighton (20). The figures refer to titles in bibliography pp.

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soils and weathered zones, which are the modified upper parts of the several till sheets, (and including also the several loesses, peat, and other nonglacial deposits) be more closely grouped with the glacial deposits in the classification, that four epochs be recognized in North America, and that they be named as subdivisions of a Pleistocene period from which

Sangamon stage of deglaciation

The melting of the Illinoian ice sheet appears to have left a nearly flat plain of which there are remnants several square miles in extent yet preserved in interstream tracts. This plain was sharply incised and generally dissected to depths of 50 to 150 feet prior to the deposition of the Peorian loess which now mantles the interstream upland tracts and the rather steep side slopes of the valleys. (Photo, p.).

Leverett early noted, and recent studies in Illinois have differentiated, a thin deposit of loess or loesslike silt overlying the gumbotil at the top of the Illinoian till and distinct from the overlying Peorian loess. It is found to be separated from the calcareous Peorian loess by a soil and weathered zone and in consequence it was concluded by Leverett (22), and more recently by Leighton (20), that the weathering and erosion of the Illinoian till, the deposition of this thin loess, and the development of the soil at its top are all features of the Sangamon interglacial stage. The indications are, however, that this stage of deglaciation, though long enough for the complete disappearance of the continental ice sheet from North America, was not nearly so long as the Yarmouth interglacial stage.

The Mississippi River appears to have assumed its present course between the south end of the Driftless Area and the mouth of the Illinois River some time after the front of the Illinoian ice sheet receded from Iowa (Schoewe, 37).

from the Wisconsin glaciation by any considerable interval of deglaciation, and by Leighton (20) that it may even be regarded as the initial ice invasion of Wisconsin age. The Illinoian and Iowan drifts, as now mapped, occupy separate areas and they do not overlap.

Peorian stage of deglaciation

Mantling the weathered and eroded surface of the Illinoian drift and the Sangamon loess and extending eastward under early Wisconsin till in Illinois is the deposit for some time called Iowan loess, but now generally known as Peorian loess. This loess also extends westward over the weathered and eroded Kansan drift of eastern, southern, and western Iowa into Kansas and Nebraska and the borders of southeastern South Dakota. It overlaps the Driftless Area and the marginal parts of the Iowan drift in Iowa and adjacent parts of Minnesota and it extends under the late Wisconsin drift of the Des Moines lobe. (Photo, p.). There is difference of opinion as to the amount of erosion and length of time that were required to form sparse, residual-pebble accumulations which are found on top of the Iowan till and beneath the loess and present knowledge is not sufficient to settle this question, but to some geologists the time required does not seem to be long. Other conditions seem to indicate that the deposition of the Peorian loess followed the recession of the ice from the Iowan drift plain after a comparatively brief period. There was a moderate amount of leaching (4 to 5 feet) and oxidation of the loess before it was overrun by the late Wisconsin ice of the Des Moines lobe. Leverett (22) and more recently Leighton (20) have found evidence of very

moderate weathering of the Peorian loess before it was overrun by early Wisconsin ice which formed the Shelbyville moraine. The Iowan drift is generally thin and it has been but little dissected (photo, p.), although subjected to sufficient erosion to account for the residual pebble accumulation. This drift has in general about the same buff tint as the Peorian loess, where thin; where thicker the color shades downward into gray below the zone of oxidation. The calcareous material is yet present within 3 to 5 feet of the top and in many places clear up to the base of the overlapping loess. The main deposit of loess, which is so generally presant on the pre-Wisconsin drift, south and east of southeastern South Dakota and in the Driftless Area, is now generally considered an eolian deposit. The included fossils appear to indicate climatic conditions not greatly different from those of Recent time. The fact that a goodly thickness extends under the Wisconsin drift in both Iowa and Illinois has led to its reference to the Peorian interglacial stage. There are thicknesses of 50 to 100 feet in many places in the bluffs bordering Missouri and Mississippi Rivers and some of the tributary streams, but the deposit thins rapidly on the interstream areas with increasing distance from the alluvial flats which appear, in large measure, to have been the local sources of supply for the dust.

Loess mantles the slopes and uplands in the Driftless Area; it borders the Ohio River eastward to West Virginia and there is a broad belt bordering the Mississippi lowland on the east in Kentucky,

Tennessee, and Mississippi. It is present in southeastern Missouri, caps Crowley Ridge, Ark., and a narrow belt borders the Black River lowland on the west about half the distance southwestward to Little

Glacial lakes

The recession of the Wisconsin ice fronts northward and northeastward across the divides caused ponding of water in the several basins up to the levels of spillways leading to tributaries of the Mississippi River. The outlet of glacial Lake Agassiz, in the basin of the Red River of the North, was by way of Minnesota River Valley; glacial Lake Duluth in the Superior Basin had an outlet southward by the St. Croix Valley; glacial Lake Chicago in Lake Michigan Basin discharged to the Illinois River Valley, and glacial Lake Maumee found a spillway southwestward from the Erie Basin to the Wabash River. Later there were outlets eastward to Hudson River Valley and to Ottawa River Valley when glacial lakes Algonquin and Iroquois and the Nipissing Great Lakes occupied part of the basins. Deepening of outlets, opening of new ones, shifting of the ice fronts, and tilting of the basins, as indicated by the abandoned shore lines, differentiated stages of a complicated glacio-lacustrine and post-glacial lake history covering the Great Lakes basins.[1/] The abandoned

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1/ Upham (47), Leverett (23 and 26) and with Taylor (30), Alden (1, 2, and 3), Goldthwait (10).

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shore lines are horizontal in the southern half of the Lake Michigan Basin, but in the northern half they rise gradually in a north-northeasterly direction. (Map II, p. , photo 12, p.). Among the indications of a low-water stage of glacial Lake Chicago is a buried "forest bed" near Manitowoc, Wis. There were also many other glacial lakes, some of them of considerable size.

Driftless area

A remarkable feature is that an area, more than 10,000 square miles in extent, embracing southwestern Wisconsin and small parts of the adjacent States, although entirely surrounded by glacial drift, shows no evidence of ever having been glaciated. (Photo, p.). Its protection from ice invasion appears not to have been due to any greater elevation, but to the general southerly trend of the axial movements of the ice lobes on the west, to limitations on the amount of ice available, and to diversion of axial flow by the elongated basins of Lakes

State of Wisconsin

GEOLOGICAL AND NATURAL HISTORY SURVEY

MADISON, WISCONSIN

OFFICE, SCIENCE HALL
GEOLOGY DIVISION
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OFFICE, SCIENCE HALL
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E. A. BIRGE, IN CHARGE
C. JUDAY, BIOLOGIST
OFFICE, BIOLOGY BUILDING
SOIL SURVEY DIVISION
A. R. WHITSON, IN CHARGE
OFFICE, SOILS BUILDING

April 18, 1931

Mr. F. T. Thwaites
Science Hall

Dear Fred:

Am enclosing your schedule, my write-up of the first day and a half, and all of the data from Alden. Wish you would keep this altogether so that the files will be complete, and get your material in shape so that we can have a conference on this soon. I think you and I are entirely agreed on some things, but I am inclined to think that we shall have to consider some features in the light of the fact that these men are strangers who will be interested in things not necessarily glacial geology. These would be the University, Devils Lake, the Dells, etc.

Very truly yours

WISCONSIN GEOLOGICAL SURVEY
By E.F.B.
Director

EFB LMV

enc.-

Memorandum for authors of guidebooks

The Organization Committee at its meeting on April 26 voted to postpone the meeting of the International Geological Congress for a year, to the latter part of June, 1933. It was felt that the generally adverse economic conditions throughout the world made this postponement desirable.

Although the additional time for preparation will make possible better and more thorough planning of details of the excursions, not much additional time can be allowed for the guidebook manuscripts, since our appropriation of $15,000 for this purpose is only available for the fiscal year beginning next July 1 (1931). Therefore, the sooner the manuscripts are prepared the more time can be devoted to editing and preparation of illustrations, two important tasks which would inevitably have been hurried under the old arrangement.

Guidebook manuscripts should therefore be submitted as early as possible and preferably not much later than July 1.

Preliminary estimates of length indicate that we shall probably have more material submitted than can be published within our appropriation. Therefore authors are again urged to be as concise as possible.

The size of the guidebook is to be the same as those of the South African Congress, 5½ x 8½ inches, but with slightly smaller margins, so that the space occupied by print will be 3 7/8 x 6 1/2 inches. Probably this will run about 400 words to a page.

Manuscripts should be in double or triple space typewriting, including footnotes. If cuts of previously published illustrations are available and conform to this size they should be used. Where published line drawings of a larger size are available they can be used without redrawing to have new cuts made. Half-tone cuts too large for the page can not be used; a new photograph must be furnished, unless available in the Geological Survey files.

If it can be done conveniently it is of course desirable to have the illustrations in shape for publication without redrawing, but if necessary a rough draft can be submitted and the drafting done in the Geological Survey office. If this is done the sketch should be so clear that the draftsmen can complete the illustration without further reference to the author. For many illustrations it will probably be desirable that all work except the lettering be done by the author and the lettering added in pencil, to be redrawn. Where a one color overprint for whatever color is desired, the colored lines should be indicated by a blue pencil (since blue does not photograph), not ink, or an additional tracing furnished showing the part desired in color with sufficient tie points, such as section corners, etc., to allow its accurate superposition.

It now seems unlikely that colored maps can be printed, but if such a map is thought absolutely necessary, the manuscript and proposed map should be submitted early, so that it may be considered by the editorial committee, and, if approved, work on the map begun promptly.

Only photographs that will reproduce clearly should be used. For many views, as suggested earlier, line drawings made from photographs are preferable. Prints for reproduction should be on glossy paper. If superimposed lines or letters are to be used on photographs, furnish two prints, one dull with the lettering desired, the other glossy.

Chairmen of committees are expected to secure the manuscripts from authors of the different portions of their guidebooks in sufficient time to combine and harmonize them and give them the necessary preliminary editing. If it proves impossible to get the manuscripts in reasonable time from all those sharing in the authorship, it is recommended that the manuscript available be submitted without waiting too long for the delinquents, who should be warned that delay may make it necessary to publish the guidebook without their sections.

Since the guidebooks are to be Survey publications it is proper to use franks for the submission of the manuscript and illustrations, and a few are inclosed herewith.

INTERNATIONAL GEOLOGICAL CONGRESS

XVITH SESSION, U.S.A., 1932

GENERAL SECRETARY

U.S.GEOLOGICAL SURVEY, WASHINGTON, D.C.

CABLE ADDRESS
INTERGEOL WASHINGTON

May 2, 1931.

Dr. F. T. Thwaites,
University of Wisconsin,
Madison, Wis.

Through Dr. E.F. Bean.

Dear Doctor Thwaites:

I have your letter of April 23 and will give consideration to your suggestions in revising my manuscript. Thanks for them.

Please send me a rough sketch of what you would want to show on your proposed sketch map of eastern Wisconsin. I had thought of using Leverett's map, Fig. 5 of Professional Paper 154-A,-Lake Superior region. Do you think we would want both? I think Leverett's map could probably be put in, folded as a double page plate. Leverett wishes the explanation blocks grouped so as to show early, middle, and late Wisconsin substages.

I am inclosing a copy of a memorandum for authors of guidebooks of the International Geological Congress.

You will note that, although the Congress is postponed to 1933, the time for preparation of the guidebook is not extended, and I will have to delay leaving for the West until it is ready. Can you let me have your contribution to the itinerary notes some time during May or early in June?

Very truly yours,

W. C. Alden

Geologist.

COMMENTS OF MS OF "QUATERNARY PERIOD IN THE MISSISSIPPI BASIN"

p. 1 I object to the prominence given to the supposed preglacial peneplains. After 15 years study in the Driftless Area I am as far as ever from acdepting such a theory. The fact that Trowbridge was obliged to abandon the outworn idea that each limestone upland is a dissected base leveled surface makes the idea of old erosion surfaces rest soley upon (a) the fact that a warped plne can be passed through the crests of the cuestas, and (b) the fact that the vales between cuestas are of subequal evevation. The uplands on the cuesta crests is continuous down the backslopes to that of the vales and the same kind of country exists throughout. I can see some suggestion of a general peneplain which accounts for the crests but I fail entirely to get any suggestion of a lower plain. The upland of the Baraboo Bluffs does not fit in at all with either plain. These and other serious objections have been set forth by me in publications and given to Martin for use in his proposed revision of Bull. 36. I regard the matter as highly controversial and not worthy of much serious energy since if any peneplain remnants are still left they could explain only a minute part of the uplands, namely parts of the cuesa crests. I suggest minimizing the whole matter. The relation of the drift to the inner gorge of the Mississippi is another matter. There is no doubt that much erosion has taken place since the Nebraskan glaciation.

p. 2 Is not Leverett's Nebraskan driftin deep erosion valleys based soley on well records and not worthy of much serious throught?

p. 3 How about placing the Jerseyin whose relations are not clear, after the Kansan where Leverett now suggests it belongs? As pointed out by me in my paper on multiple glaciation as well as in my Outline of Glacial Geology it seems as if the eastern geologists may have made several blunders in trying to correlate the seabord drifts with the Mississippi Valley. Since your paper is on the latter only why not omit this?

p. 5 I would add that Kay regards the Aftonian gravels as glacial outwash. I suggest that the organic remains in them were brought in from tributary streams

p. 7 The famous well at Yarmouth must have been dug rather than drilled.

p. 8 Should it not be Illinoian stage of glaciation? Should not the formation of SILTTILL be mentioned?

p. 9 p. 9 When "complete disappearance" is mentioned do you not mean recession of the ice caps to something like present conditions? See Outline of glacial geology. In that I have suggested that the present course of the Mississippi may not have been assumed until the early Wisconsin invasion but may have been to the Illinois River between Illinoian and early Wisconsin times.

p. 10 The thing which always puzzled Martin and me was not the verity of a post-Kansan till in northeastern Iowa but the wierd and impossible bundaries given to this ice invasion. Since studying the late Wisconsin red till in northeastern Wisconsin I have been converted to the view that a much larger area was covered by the Iowan ice than Calvin's maps indicate but that in the rougher country the identity of the invasion has been lost by postglacial weathering and erosion. I suggest that the question now is simply of correlation and time relations. I personally favor the assignment of the Iowan to the earliest Wisconsin.

p. 12 May not much dust have also come from the deserts? I suggest comparison of present day floodplain dusts with desert dusts.

State of Wisconsin

GEOLOGICAL AND NATURAL HISTORY SURVEY

MADISON, WISCONSIN

E. F. BEAN
DIRECTOR OF SURVEY AND STATE GEOLOGIST
OFFICE, SCIENCE HALL

GEOLOGY DIVISION
H. R. ALDRICH
ASSISTANT STATE GEOLOGIST
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NATURAL HISTORY DIVISION
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A. R. WHITSON, IN CHARGE
OFFICE, SOILS BUILDING

p. 13 The differences between the clay till regions and the stony drift regions which have much outwash, steep moraines, kettles, etc. etc. is not brought out very well. The coal measures regions show the flat drift plains with low smooth moraines. The old drifts extended farther into these shale regions than did the Wisconsin except in central Illinois and central Iowa.

p. 14 I think a sketch map of eastern Wisconsin based in part on my unpublished results which would show the relative changes in lobation of early, middle, and late Wisconsin would be a good illustration. If you desire I will prepare the same with help of Dr. Leighton for northern Illinois.

p. 15 The Forest Bed of Two Creeks deserves mention here. I venture to make another suggestion. Since the late Wisconsin of the eastern part of Wisconsin is clearly a Patrician advance past the iron regions of northern Michigan I wonder if the outer Wisconsin moraine of northwestern Wisconsin (red drift moraine) may not be late instead of middle Wisconsin. I cannot quite reconcile the different striae there on the basis of lobation. They look like change in source of ice possibly while the lake basin was still filled with stagnant Labradorian ice. The existance of stagnant ice masses was long ago suggested by Martin and was apparently not thought of by Leverett. If this wild idea is correct then we might have four instead of three Wisconsin invasions, the Wisconsin of Iowa being the latest. I simply give this to think about not to be regarded as a final opinion. Anyhow, I cannot see Leverett's readvance of the Labrador glacier in the Lake Superior basin.

p. 17 In view of fact that the party will see the beaches of Lake Chicago would not a fuller description of the history of that basin be in order possibly at expense of eliminating some of information on eastern U. S.? I would included my (radical) suggestion that the low water stage marked by the Forest Bed occured within Glenwood time. In other words we may have an early Glenwood stage which is late middle Wisconsin and a late Glenwood stage which is post late Wisconsin. Or maybe the supposed post-late Wisconsin beaches at Glenwood level were originally covered with a thin layer of red till removed by later erosion and destroyed by later weathering. I have seen lots of examples of this in northeastern Wisconsin.

p. 17 The stock explanation of the Driftless Area given first by Irving and Chamberlin has been repeated again and again without thinking that when worked out it was thought that all ice came from Labrador. When the vast southern extension of ice occured in Kansan time why was the Driftless Area not glaciated? Was there also a Patrician glacier which not only carried copper southeast from Keweenaw Point but blocked the western ice from spreading as far east as the Mississippi gorge? I cannot answer these questions but put them out as food for thought. Another thing which should be brought out is that the present topography of the Area is not preglacial but may be like the pre-Wisconsin topography of the adjacent regions. Even if we do not accept all of Trowbridge's ideas the region underwent much interglacial erosion.

April 23, 1931

Dr. W. C. Alden,
U. S. Geological Survey,
Washington, D. C.

Dear Dr. Alden:

Your letters of April 10 and 14 have gone a long time unanswered. Field trips come so frequently at this time of year that I do not get much time to catch up on letters which work has to be done at home during evenings or on mornings when I have no classes.

Mr. Bean has turned over all the data you sent to him and I am working on the detailed description of the proposed route. I am much pleased that you have accepted my changes and am positive that you will not be sorry. We must hope for a strong northeaster not long before the trip also for a higher level of Lake Michigan!

I have written some comments on your manuscript which I hope you will see fit to consider and not think a presumption on my part.

Have you a copy of the mimeographed Outline of Glacial Geology, edition 1927? If not I will mail you a copy as it gives things in more detail. It will be revised soon, I hope.

I gave Mr. Bean two suggestions which he thought good: (a) that he or I go over the proposed route a few days in advance of the party and make all arrangements for stops and a tentative time table, (b) that we make up a book of photographs of things seen along the route and allow members of the party to order whatever ones they wish. The latter may serve to save some time which members would otherwise take for photography.

Hope to hear from you about the northeastern Wisconsin reports soon. I may be able to get up a field course there this summer. The govenor has vetoed the Survey appropriation.

Verytruly yours,

Lecturer in Geology

INTERNATIONAL GEOLOGICAL CONGRESS
XVITH SESSION, U.S.A., 1932
GENERAL SECRETARY
U.S.GEOLOGICAL SURVEY, WASHINGTON, D.C.

CABLE ADDRESS
INTERGEOL WASHINGTON

April 14, 1931.

Dr. F.T. Thwaites,
c/o Dr. E.F. Bean,
University of Wisconsin, Madison, Wis.

Dear Doctor Thwaites:

I met Kay and Leighton in Chicago Friday, April 10, and discussed with them very briefly the proposed changes in the schedule of the 1932 excursion. From their experiences with excursions, they feel quite strongly that the shcedule should not be planned to run after supper, and that the tendency is to plan too much for a day's run and to rush the party too much. The trips in Wisconsin should therefore be adjusted by you with this in view.

Leighton does not object to making the final trip Harvard, Ill., region to Chicago. He favors dropping the eighth day trip of the former schedule (Chicago to St. Joe, Mich., and return).

Very truly yours,

W. C. Alden

Geologist.

INTERNATIONAL GEOLOGICAL CONGRESS

XVITH SESSION, U.S.A., 1932

GENERAL SECRETARY

U.S.GEOLOGICAL SURVEY, WASHINGTON, D.C.

CABLE ADDRESS
INTERGEOL WASHINGTON

April 10, 1931.

Dr. F.W. Thwaites,
c/o Dr. E.F. Bean,
University of Wisconsin, Madison, Wis.

Dear Doctor Thwaites:

I wish to thank you for your letter of April 1 and your suggestions concerning the glacial excursion of the International Geological Congress. I expected Dr. Bean to confer with you and others in arranging the itinerary and the notes for the guidebook. What I sent was largely in the way of suggestion as to what might be done. Whether we go as far northeast as Manitowoc and Two Rivers, Wis., depends on whether or not the distance can readily be covered in the time available; weather conditions must also be taken into account. It may not be necessary to spend much time on the Wisconsin terraces or to go through Madison, but go directly up Wisconsin Valley to Baraboo. See accompanying sheets for suggested changes.

It may be better, as you suggest, to continue awhile after supper. Nine o'clock might not be too late to run into the place of night stop. I do not think the days should be too crowded, but you folks who are handling field classes probably know better than I what can be done. I am inclined to think it better to go east across the head of the drumlin area rather than by way of Montello and Ripon.

We will, of course, not need so much in detail for the guidebook as you have in the schedules for your class trips.

I am sending this letter through Dr. Bean and am forwarding copies of it to Doctors Kay and Leighton. You folks can go ahead on this schedule and I will let you know if Kay and Leighton have any adverse comments.

Very truly yours,

W.C. Alden
in charge

Inclosure.

Geologist.

Suggestions for revision of schedule of Glacial

Excursion for International Geological Congress, June, 1932.

Third Day

(See former schedule).

End at Prairie du Chien, Wis., instead of West Union, Ia.

Fourth Day

Go up Wisconsin Valley over Bridgeport et al. terraces; outwash and moraine north of Prairie du Sac and north of Baraboo; see some Driftless Area; Baraboo bluffs and gaps; north to Kilbourn; Dells of Wisconsin River.

Fifth Day

East via Portage, Beaver Dam, Horicon, across head of drumlin area; north to Fond du Lac, or on to Manitowoc.

Sixth Day

Forest bed between middle and late Wisconsin deposits near Two Creeks; varved clays and beaches; Manitowoc to Valders quarry where crossed striae show shift of movement (may omit Valders); south to see overlap of late Wisconsin red drift on middle Wisconsin moraines; west through moraines and drumlins, to Niagara escarpment; red and gray drift; moraines and drumlins and eskers south (possibly Iron Ridge?) to Oconomowoc.

Seventh Day

South, - recessional and interlobate moraines, lakes and terraces; Richmond interlobate angle, moraines and terraces and buried valleys to Lake Geneva region and south to Harvard, Ill.

Eighth Day

(Seventh day of former schedule) - Harvard, Ill., region to Chicago, and omit the trip to Indiana and Michigan suggested before for the eighth day.

April 1, 1931

Dr. W. C. Alden,
U. S. Geological Survey,
Washington, D. C.,

Dear Dr. Alden:

I was informed yesterday that the route for a glacial geology excursion of the International Geological Congress through this state had already been decided upon. This was the first official intimation I had received that such an expedition was planned.

Mr. Bean informed me that three entire days are alloted to this state. It seemed to me that with my experience in taking classes in glacial geology on such automobile trips gained during the last ten years I might be able to offer some suggestions before it is too late.

With this thought in mind I am enclosing route directions for the two two day trips as taken last spring. Of course I thoroughly realize that some of the things we take in are hard to reach and that the details would of necessity have to be changed to suit the different needs of the proposed trip.

I beg leave to suggest that if at all possible the interglacial forest bed at Two Creeks be visited. So far as I know that is the only chance foreign geologist would have to see a true interglacial forest. Although now only very briefly described in published material the deposit is well worth seeing. I have had a graduate in botany working on the remains for nearly a year. He has some 19 species of mosses, some new to North America, 7 species of mollusks, as well as other things such as trees, beetle excavations, mites, fungi, etc. The deposits show the relations between the Late and Middle Wisconsin drifts in a remarkable manner. Nearby one can also see post-Late Wisconsin beaches and varved clays, the clay pit at Manitowoc in which the varved clays lie in the same stratigraphic relations as at the Forest Bed, and the crossing striae at Valders, now better understood than when you saw them so long ago. On the way to the region one could also visit the drumlin belt east of Fond du Lac which I now interpret as evidence of a change in ice direction between Early and Middle Wisconsin times.

I make bold to suggest the following itinerary: First day, start at Prairie du Chien and pass lightly over the Bridgeport terrace which in present state of knowledge is not well understood; keep on up the Wisconsin valley to Prairiedu Sac and night at Baraboo, with some side trips into typical Driftless topography. Second day, the Dells, then

east through rather uninteresting country to be sure but past Montello granite, Ripon gravel seam (if worth while?) and Green Lake to Fond du Lac for night although possibly Manitowoc might be reached. Third day, the Fond du Lac drumlin region, the Late Wisconsin border now well seen in cuts on Highway 23, Valders quarry, possibly Manitowoc clay pit, the Forest Bed, then go south along the interlobate moraine to Hartford or Oconomowoc. At the time of year suggested for the exdursion it is desirable to travel rather late in the evenings since the time after dinner is apt to hang rather heavy. When trips are made late in the spring I often run until 9 P. M. This program would involve slightly lengthening the stay in Wisconsin for the interlobate angle and the drumlins would have to go over to the fourth day. However, on thinking it over I am not sure about this. Too much time is given to the first day. I rather think that the night could be spent at Kilbourn. Then the second night at Manitowoc and the third at Lake Geneva.

I have found that 150 miles is about the limit of a days run if there are many stops but if you continue after dinner than 200 miles is not too much. However, it is best not to make such an excessive distance for more than one day. Otherwise everyone gets too tired.

In the southern part of the state I have little to suggest. Drumlins are well shown along Highway 30 west of Delafield. The angle between the Darien or West Chicago and the Marengo Ridge moraines in northern Illinois should not be missed as it is most instructive as to a lapse of time between Early and Middle Wisconsin time.

I trust you have not forgotten my last suggestion as to cause of the red color of the Late Wisconsin in northeastern Wisconsin namely that the ice of that substage came from the Patrician center past the Marquette and Gwin iron districts.

I hope you will not think it presumptuous for me to offer these suggestions,

With best regards,

Very truly yours,

Lecturer in Geology

For W E T Thompson, Jr
Not to be given away
when finished please
return to me.

ROUTE LOG FOR EXCURSION C-3, 16th INTERNATIONAL GEOLOGICAL CONGRESS
GLACIAL GEOLOGY OF THE CENTRAL STATES

Prepared by F. T. Thwaites, University of Wisconsin

Note: On account of the uncertainty in regard to carrying out the trip all of the route was not logged. Several cars were used and the mileage readings have not all been corrected. Data on the parts not logged were taken from topographical and highway maps. Drivers should reset speedometers from time to time as no two such instruments ever check exactly. The writer is personally responsible for all statements and opinions herein expressed. See Guide Book for interpretations held by U. S. Geological Survey.

August 3, 1933

0.0 Junction U. S. 18 and Wis. 27 in Prairie du Chien. Turn right, south, on 18.
7 min. run over very level sandy outwash plain of Wisconsin glaciation. Bluffs to left 560 ft. high, capped with Galena dolomite.

3.4 Bridgeport terrace on left. See Guidebook. Enter valley eroded in terrace.

3.7 STOP 1 10 min. Park cars in side road to left. Cut shows pebbly sand of 125 ft. terrace (740 A. T.) banked against side of Lower Magnesian dolomite bluff. This material in which the bedding dips east is probably a slack water deposit on downstream side of rock hill. It may be much younger than the highest or 190 ft. terrace. Proceed either on foot or in cars to visit new cuts in high terrace along U. S. 18. Shovel will be needed.

4.9 STOP 2 20 min. Discussion of Bridgeport terrace hypotheses. (a) Till of Kewatin glacier, (b) outwash from Kewatin glacier, (c) outwash down Wisconsin River at time when rock bottom was higher than at present. Under last hypothesis all traces of this level have been destroyed upstream where bed rock is sandstone instead of dolomite as it is here. An erosion interval then followed and the terrace was dissected before the 100-125 foot filling was deposited. These terraces were in turn eroded before the earliest Wisconsin glaciation. Attention should be directed to character of the pebbles and to direction of dip of foreset bedding. 30 min. run to next stop.

5.9 Junction with Wis. 60. Keep left on 60.

10.0 Leave Bridgeport terrace. The writer interprets several of the valleys in the terrace as superimposed on an older rock topography as a result of valley filling.

17.0 Wauzeka. Cars will leave main highway to pass gravel pits in old terrace deposits. STOP 3 here or on ridge 1 mile above. 15 min.

19.0 Mouth of Kickapoo Valley. Note "underfit" stream in small meanders on floodplain within huge entrenched or ingrown bends. Higher up the valley some such bends have been cut off probably as result of pre-Wisconsin valley filling. Such phenomena do not prove decreased volume of the Kickapoo but rather the change in conditions due to alluvial fill in response to blocking of outlet by glacial outwash.

20.0 STOP 4 Gravel pit at Porter School 20 min. This pit is in what the writer interprets as a terrace younger than the highest Bridgeport terrace. It is 75 to 100 feet above the river and moderately eroded. 15 min. run to next stop.

Boscobel

27.0 ~~Bridgeport~~ bridgehead. STOP 5 Climb Easter Rock 350 ft. high for discussion of terrace problem and physiography of Wisconsin Valley, 30 min. stop. 1 hr. 20 min. run to next stop.
Turn right onto U. S. 61 and cross terrace of Wisconsin River at Boscobel. Two Wisconsin terraces are present. The lower one is 12 to 15 ft. above the floodplain and was eroded from the higher terrace by the waters

from Glacial Lakes Oshkosh during the retreat of the Middle Wisconsin and during Late Wisconsin time. The higher terrace was deposited during the formation of the Middle Wisconsin.
Continuing south from Boscobel on 61 we ascend the course of Crooked Creek. As in all other tributaries which head in the Driftless Area, this valley was aggraded to meet in part at least the filling of outwash in the main stream which carried glacial drainage. Meandering on such fill has led to the formation of rapids and falls wherever the stream found itself superimposed on rock spurs when erosion of the filling permitted entrenchment.
The stratigraphic column south of Boscobel includes in ascending order the highly glauconitic Franconia sandstone (Cambrian), the yellow and red dolomitic siltstone and gray fine grained sandstone of the Trempealeau formation (Cambrian), whose top was formerly called Jordan, the gray dolomites of the Lower Magnesian group (Oneota and Shakopee, Ordovician), the soft but crag-making St. Peter sandstone (Ordovician), the Platteville dolomite and limestone (Ordovician), and the Galena dolomite (Ordovician),

41.0 Fennimore. Turn left with U. S. 18. From here east the route follows the famous Military Ridge which is the crest of the Galena-Platteville Cuesta. The country is more rolling than is apparent to the eye, for the subequal elevation of the ridges blends in the distance into the semblance of a plain. This "plain" constantly retreats from the observer like a "will-o-the wisp". As a matter of fact the upland is typical "dolomite topography." Note scarcity of sink holes. The steep-sided valleys occur only where erosion has cut through to the sandstones. Early geologists assumed that this upland was a remnant of a peneplain and that the same surface extended to the north beveling across the older formations. It is known, now that topographic maps have been made, that such is another illusion. There is really a marked series of dissected cuestas whose escarpments ring around the pre-Cambrian highland of northern Wisconsin. Similar uplands occur also on the Niagaran of Illinois and Iowa, the Lower Magnesian of Wisconsin and Minnesota, the Franconia sandstone in Wisconsin, and some of the shale horizons in the Eau Claire formation (Cambrian) of Wisconsin.
An important factor in their formation is the presence of clay or shale which acts as a roof in protecting the underlying rocks from weathering. The uplands on the dolomites bevel the formations to a slight degree, but this is a normal effect from the fact that the crests of the cuestas have been exposed to the weather much longer than have the vales where the overlying formation has been but recently removed. To ascribe every upland to former peneplanation requires too many peneplains each too closely controlled by geology to be credible. Besides, the same bench effect is noted within valleys wherever such cut down to the proper geologic horizon.
68.0 Dodgeville. Turn right and stop at Hotel Higbee for lunch. 45 min. Return to U. S. 18 and go east. 40 min. run to next stop.
86.0 Dane County line - detailed log begins.
86.5 Blue Mound. Turn left under R. R. on County Highway F.
87.0 Turn left up hill on F.
87.3 STOP 6 at entrance to Ball Park. 15 min.
Thence continue north on F.
87.8 STOP 7. 15 min. Discussion of peneplain problem. The view from here displays the reason for the early misconception of an all-embracing upland peneplain as the escarpment caused by the St. Peter sandstone (whose thickness varies greatly) is invisible from behind. Trowbridge abandoned this idea in favor of two peneplain levels. Of these the older (Dodgeville) accounts for the crests of the cuestas and for the level upland of the Baraboo Range (Huronian quartzite) which can be

soon from here. The lower surface (Lancaster) lies roughly 200 feet below and accounts for the upland on the Lower Magnesian north of here. It also occurs on the bluffs along Mississippi River and in the vale south of Military Ridge cuesta. Trowbridge regards the ridge north-east of Prairie du Chien between Mississippi and Kickapoo rivers as a "bridge" between the Dodgeville peneplain on the cuesta of Military Ridge and on the Magnesian cuesta to the north. Although recognizing the possibility of this explanation the writer begs to ask some questions: (a) How is it that there is no difference in degree of dissection of the Lancaster and Dodgeville surfaces?, (b) How is it that at all points rock control is the dominant factor and is capable of explaining all the facts?, (c) How is it that one finds exactly the same type of topography down the back slope of every cuesta making a transition between the two upland surfaces?, (d) Why should an uneroded remnant of the higher surface be left between two of the largest streams rather than far from streams?, and (e) How can the upland of the Baraboo Range be fitted into the picture? It may be added that the "topographic unconformity" between the upland and valley sides is everywhere capable of explaination by rock control, and that the upland gravels and the rare ingrown bends do not in themselves prove much. Turn cars around and return south on F. 30 min to next stop.

88.5 Turn left on town road.
88.6 Sink hole on right
89.2 Rejoin U. S. 18, keep ahead on 18.
100.2 St. Peter escarpment poorly developed as sandstone is thin here.
100.9 Terminal moraine ahead on skyline.
103.0 STOP 8. 10 min. Park cars just east of R. R. clear of pavement. Walk back and up track to see post-Illinoian rock gorge due to diversion of stream by Illinoian terminal moraine. Turn back to cars and continue on 18. 7 min. to next stop.
103.2 Illinoian terminal to left indistinguishable from rock hills.
103.5 Cut in old drift overlying disintegrated Lower Magnesian dolomite. DRIVE SLOW to see boulders in residium.
104.0 Johnstown Moraine east of stream. Continue on 18 to
104.8 Verona, there turn right onto Wis. 69 south on main street.
105.2 Turn half right with 69.
105.8 STOP 9 to see gravel pit in outwash just outside moraine of Middle Wisconsin. 10 min. 8 min to next stop. Turn cars around and retrace way out going west on 18 to edge of terminal.
107.6 Turn right into town road.
108.4 STOP 10 10 min. On crest of Johnstown Moraine. Unglaciated or possibly old drift covered hill across ravine cut by marginal drainage. 10 min to next stop.
108.9 Turn left leaving terminal moraine. Loess-covered outwash terrace eroded by waters from east of endmoraine.
109.8 Turn left (west).
110.0 Turn right on outwash terrace soon reaching foot of terminal moraine.
111.1 STOP 11. 5 min. Drainage outlet through Johnstown Moraine. Continue ahead, 15 min to next stop.
111.7 Turn left. CAUTION: use second speed descending hill.
112.3 Turn right. St. Peter outcrop. This country unglaciated.
113.3 Turn right and immediately left. Road relocated since map.
114.5 STOP 12. 10 min. 3 min to next stop. Depression enclosed by endmoraine.
115.1 CAUTION: cross main road, keep ahead.
115.2 STOP 13 To see underground outlet from depression. 3 min. 6 min. to next stop.
117.0 STOP 14. Cut in terminal moraine which here bends west into valley to north. Very bouldery till. 5 min. Turn right (north). CAUTION: use second speed on steep descent. 10 min to next stop. Continue to Wis. 11.
118.0 Turn left onto 11 and go west crossing low endmoraine (Johnstown).

119.5 Turn left into side road. STOP 15. 15 min. 35 min to end of day's run. From this point the contrast between the craggy hills of the Driftless Area and the smooth rock hills of the glaciated area is most striking. The endmoraine itself is, however, not very conspicuous as it is covered by outwash and eroded by drainage from farther east. Note boulder concentrate along the stream caused by waters from second or Milton Moraine. 2/10th mile down this road is a gravel pit in the outwash. For many years the Driftless Area has been held up to students as an example of what the adjacent glaciated country looked like before glaciation. It is necessary to realize that not all of the glaciated country originally had as rough topography as here. From East Blue Mound the contrast between the very dissected country north of Military Ridge and the dolomite uplands to the south is very clear. We must also distinguish between preglacial and pre-Wisconsin. Assuredly much erosion went on in the Driftless Area during the Pleistocene. However, most geologists do not agree with Trowbridge in thinking that the "Lancaster peneplain" was dissected almost entirely since Nebraskan time. Many years ago Chamberlin and Salisbury tried to measure the importance of glacial erosion in smoothing the glaciated area by comparing the average depth of residium in the Driftless Area with the average depth of drift in the glaciated district. Although they seem to have underestimated the former the fact that much of the drift clearly was derived from comparatively fresh bed rock is conclusive evidence in favor of glacial removal of crags, ledges, and small hills. This fact is here demonstrated. On the other hand, the writer has always been conservative in accepting glacial erosion of large basins as at Madison or in the Great Lakes. Continental glaciers lacked the sloping basement of mountain glaciers. They were not ice rivers and active flow must have been confined to a marginal belt of possibly 150 miles. This belt of moving ice migrated outward during glacial expansion. The main advantage of a glacier over a stream in erosion is the plucking of large masses of broken bed rock. Abrasion must have been unimportant. Over much of the glaciated area considerable decomposed rock is left and the forms of the hills are not related to direction of ice movement. Turn cars around and return to 11.

ROCK

119.9 Turn right onto 11 and retrace route for some distance. Keep on 11.

121.0 Narrow place in valley is preglacial divide between Wisconsin and Rock basins. Glacial deposition moved the divide to east of Middleton.

122.5 Marked recessional moraine, part of Milton system. Ice must have still been moving to make this moraine. East of here valley is occupied by pitted outwash for several miles.

124.5 Ice contact face. Flat on left was site of postglacial Extinct Lake Middleton. (See again tomorrow.)

125.4 Middleton. East shore of lake. Pick up U. S. 12 and keep ahead.

126.2 Curve right with 12. Outer edge of main part of Milton Moraine.

127.3 Turn left off 12 on paved road. From here follow lake shore drive. Most of the hills are made of rock much of which is deeply weathered. This makes extensive glacial erosion of solid rock improbable. Maximum depth of drift near Madison 372 feet below lake level. Maximum depth of lakes 80 ft. Hills at the University are composed of sand and silt with some till on side toward lake. Appear to be a slumped or shoved deltaic moraine deposited when ice had shrunk into lake basins and may have become stagnant. Several hills in the city are perfect drumlins.

132.0 Night stop at University Club on State St.

August 4, 1933

0.0 Corner of Park and University in Madison. Keep west on U. S. 12.
7.1 Turn right (north) in Middleton. 50 min. to first stop.
7.6 Cross Pheasant Branch. Postglacial stream piracy has drained Extinct Lake Middleton into Lake Mendota. Former outlet was to west to Wisconsin River. This process would in time restore the preglacial divide. Beyond the lake basin country is thinly drift-covered rock hills.
13.8 Pitted outwash plain in valley.
15.1 Gravel knolls of a higher outwash terrace or kame terrace.
17.1 Divide between Yahara and Wisconsin drainage. Note kettles on hill tops. In such rough country the ice probably stagnated soon after reaching its maximum. It is difficult to trace any continuous moraines. In clear weather Blue Mounds may be seen on left.
18.9 Pitted outwash in valley. Some morainal deposits occur along the sides but rock control is dominant.
23.5 Gravel pit on left was used for paving U. S. 12.
23.8 Valley eroded in outwash by outlet of lakes to east.
24.2 Part of Johnstown moraine to right projecting above outwash which is here cut up by postglacial gullies.
24.8 Descend from high outwash terrace to Wisconsin River.
25.1 Wisconsin River. Note the sand bars.
25.4 Turn right at traffic light. (U. S. 12)
26.5 STOP 1. 3 min. View of terminal moraine across River, eroded outwash terraces, and unglaciated hills (Round Bluff and Blackhawk Bluff). 7 min. to next stop.
27.7 Ascend from terrace to high outwash level.
28.6 Turn right into private drive to dam of Wisconsin Power and Light Co. Johnstown moraine here crosses Wisconsin River and may be seen to left.
28.9 STOP 2 Park cars on gravel and walk to edge of bluff. Opposite is Blackhawk Bluff which was a nunatak at maximum of Middle Wisconsin. Descend stairs and see to right till of Johnstown Moraine overlying outwash. CAUTION, do not leave the stairs as slope has been planted to grass to check erosion. By going down the stairs and turning right at the plant an exposure of outwash may be seen in new pit. Weidman held that this exposure of outwash under the moraine demonstrated that the terraces are of pre-Wisconsin age. MacClintock showed the error of this view. The dam is founded on sand and it has been a serious problem to prevent erosion from undermining it. 20 min. stop. Return to cars. 8 min to next stop.
29.3 Rejoin 12 and turn right. Follow 12.
31.6 Drainage outlet through moraine and stream channel in outwash well seen.
32.5 Turn left into town road.
32.9 Turn right at school house.
33.2 STOP 3. 5 min. Kettle in outwash with pond perched on silt. Note well drilled for late ex-Governor Phillip on west side. This well disclosed a layer of till below the outwash. This demonstrates a dual maximum of the Middle Wisconsin. At the first advance the ice locally went farther west than it did when the Johnstown Moraine was deposited. A block of ice was left here on retreat of the ice front. It was buried by outwash. The ice front retired several miles and the outwash seen at the dam was laid down. A readvance then resulted in the balance of movement and wastage which formed the Johnstown Moraine. The moraine of the earlier maximum is probably the Brooklyn Moraine which occurs south of Madison and was formerly correlated as probably Early Wisconsin. 5 min to next stop.
33.7 Rejoin 12. Keep ahead.
35.6 Turn right onto County Highway Z. STOP 4. 3 min. To north there is an alluvial fan at foot of Baraboo Bluffs of Huronian quartzite. The fan has been dissected and is covered with loess as is much of the

outwash. Similar gravels to those of the fan occur farther west and are known to be of pre-Wisconsin age.. 15 min. to next stop.

136.4 Pine Hollow on left, youthful gorge in quartzite in bottom of hanging valley. Cause of hanging doubtful, possibly cliff cutting of Cambrian sea.

37.0 Turn left. CAUTION: steep hill ahead, use gears.

40.4 STOP 4 35 min. Park cars close to right bank and walk to top of West Bluff overlooking Devils Lake. From this point the moraine can be seen at both ends of the Lake. History: (a) pre-Cambrian sedimentation, (b) pre-Cambrian mountain making, (c) pre-Cambrian peneplaination leaving quartzite as monadnocks and forming wide mature valleys in the bluffs such as that west of the Bluff, (d) Cambrian to Silurian sedimentation concealing quartzite entirely.(Blue Mound 1716 ft. here 1460.), (e) erosion by superimposed streams exhumed much of older topography and made new gorges with cliffy sides; gorge then 900 ft. deep, now 500, (f) early Pleistocene outwash filled gorge to about 100 feet below lake level, (g) Middle Wisconsin glacier split by bluffs to east closing in lake basin; water in lake one higher covering plains at both ends but no definite outflow channel known unless along ice front to northwest, (h) ice retired from northern part of moraine allowing waters to erode channel now followed by railway and reach level of Glacial Lake Baraboo, about 980, (i) present conditions. The level tops of the bluffs are parts of an extensive plain which varies from 1400 to 1500 feet elevation. Due to either (a) stream erosion or (b) marine planation during Paleozoic sedimentation. Time of formation either (a) pre-Cambrian subaerial peneplain, (b) Paleozoic marine plain, or (c) post-Paleozoic subaerial peneplain during removal of sediments. The writer favors marine theory because of (a) extreme flattness, (b) presence of coarse boulder conglomerate off edges of summit flats, (c) presence of residium of Paleozoic formations on upland. The famous potholes on East Bluff were formed after deposition of Paleozoic sediments and before they were eroded away. The pre-Cambrian drainage at the lake was probably to north. Later a superimposed stream (Wisconsin River) widened and deepened this valley as shown by hanging valleys southeast of the lake. Return to cars. 30 min to next stop.

41.1 Terminal moraine corsses road and continues to northwest.

41.3 Join Wis. 123 (paved)

41.4 Turn left off 123 onto Wis. 159 and go west across terminal. From terminal can see in same view (a) terminal, (b) deltaic outwash plain, (c) pre-Cambrian mature topography on quartzite (exhumed), (d) gorge due to superimposed stream, (e) upland peneplain.

42.7 Join U. S. 12 and turn right (north). Unglaciated rock ridge to west. Continue north over delta deposited by glacial streams in edge of Glacial Lake Baraboo.

43.9 Top of terminal moraine.

44.1 Leave 12 by keeping straight ahead down steep hill. CAUTION: dangerous R. R. crossing over main line of Chicago and Northwestern.

45.3 Rejoin 12 and keep straight ahead. Terminal moraine to left and ahead.

45.9 Top of terminal. Eroded edge of delta ahead.

51.8 Edge of delta whose top marks level of Glacial Lake Wisconsin in valley of Wisconsin River. Outlet to East Fork of Black River.

52.5 High hill to left has glacial pebbles on top above level of lake. Origin?

53.8 Artificial lake in post-Wisconsin gorge of Doll Creek.

54.1 Dolton. Turn right with 12. Postglacial gorges. Farther on pass into preglacial topography in Eau Claire sandstone (Cambrian). Top of Eau Claire is marked bench caused by thin layer of shale.

56.2 STOP 5. Park cars at right under trees and walk to old clay pit. 10 min. to see varved clays of Glacial Lake Wisconsin. 5 min to next stop.

56.9 Turn right onto U. S. 16. Cross river and keep to left onto main street of Wisconsin Dells or Kilbourn.

57.6 Traffic light. Character of stop at the Dells is not settled. The full boat trip takes over two hours. The Dells owe their origin to the diversion of Wisconsin River by the Johnstown Moraine to the east. Preglacial course lay east of moraine. Here the river was superimposed on a spur of Eau Claire sandstone. Erosion has produced many striking scenic features especially where the sandstone is cross bedded but the geologic and physiographic features are by no means as varied as at Devils Lake. Continue east on U. S. 16. from STOP 6. 15 min to next.

58.1 Turn right with 16. Eroded deltaic outwash.

59.6 Gravel pit.

59.9 Top of Johnstown Moraine.

63.9 Leave terminal moraine and enter big swamp. As the ice front melted back from the Johnstown Moraine the level of Lake Wisconsin was maintained until the east end of the Baraboo quartzite bluffs was cleared. Then the waters fell to the level fixed by the top of the rock spur at the Dells. Erosion of this destroyed the last remenant of Lake Wisconsin and east of the moraine another body of water, Glacial Lake Oshkosh came into existance. This had its outlet where Wisconsin River crosses the moraines above Prairie du Sac.

65.7 STOP 7. 5 min. Foreset bedding in deltaic moraine deposited in glacial lake. The regular shape of this moraine (Milton?) suggests that the glacier was moving at time of formation. 20 min. to next.

66.8 Another deltaic moraine.

75.7 Pitted outwash plain at Portage indicates that level of Glacial Lake Oshkosh in Fox and Wolf valleys to north never exceeded this level of about 830 ft. Higher beaches are known to the north but the extent to which they have been deformed by postglacial earth movement and the extent to which they are the deposits of local lakes shut in by an irregular ice margin has not been determined. After the retreat of the Middle Wisconsin ice Lake Oshkosh ceased to exist. It was brought back again by the readvance of the Late Wisconsin. The beaches of this later lake have almost certainly not been deformed.

77.2 Portage. Route from here to Waupun not logged. Lunch at Hotel Raulf For several miles east of Portage the route is over a pitted outwash plain apparently formed by drainage from isolated stagnant ice masses left in valleys to the east during the recession of the Middle Wisconsin. The paucity of moraines formed of till and therefore the product of moving ice strongly suggests that intervals of stagnation affected the ice sheet at least toward its edges. Such a condition could be brought about by lack of snowfall. Then the edge of the iceshoot would flow out until equilibrium was reached. Movement might be reinstated either by increased precipitation or by melting back of the margin to a steeper slope. About 1 hr. 45 min. to next stop. Highway 33 to Fox Lake.

107.0 Cross Green Lake Moraine.

108.0 Fox Lake. Leave 33 and pick up Wis. 68.

119.0 Waupun. Pick up U. S. 151, straight ahead.
Between Waupun and Fond du Lac the route crosses the Waupun, Rush Lake, and St. Anna Moraines, an important group of recessionals which are probably the product of a readvance of the Green Bay Lobe.

125.5 Esker on right

128.2 Note Niagara escarpment on right.

130.2 Lamartine. Outcrop of Galena dolomite instream bed. Ridge to east is St. Anna Moraine.

134.3 Mordinal ridge at border of red drift or Late Wisconsin. The red till probably mantles a ridge of the Middle Wisconsin gray till. The color which is so characteristic of the Late Wisconsin in this district is due to two factors; (a) during the recession red clays colored by drainage from the iron ranges of northern Michigan were deposited to be later

plowed up by the ice making a very clayey till, and (b) the Late Wisconsin ice in this region came from the Patrician center and thus passed directly across some of the iron ranges. South of this ridge a glacial lake discharged to Rock River through Horicon Marsh which was then a lake.

137.5 Fond du Lac-traffic light. Turn left and then turn right at next corner onto County Highway T. We are now in bed of Lake Oshkosh.

140.4 Turn left (north) onto County Highway K.

141.0 STOP 7. 10 min. Gravel pit showing marginal deposits of Middle Wisconsin overlain by red clay of Later Glacial Lake Oshkosh and thin red till of Late Wisconsin. 2 min. to next stop.

141.7 Turn left onto Wis. 23.

141.9 Turn left into gravel pit for STOP 8 805 ft. bar of Later Lake Oshkosh showing red clay stain and lenses of perfectly assorted gravel. Bar must have been built by northerly winds blowing off ice. Return to road corners to east. 15 min to next stop.

142.1 Turn left north on K and go north along foot of Niagara escarpment. Note that springs on top of underlying shale have caused much post-glacial sliding.

144.2 Turn right onto Wisconsin 31.

144.5 Turn left at Peebles following 31. From here north the highway follows on or close to the 805 ft. beach of Later Lake Oshkosh. Maximum level of 830 ft. is not shown well here.

148.4 Turn right onto County Highway Q and make STOP 8 at top of steep rise. 10 min. The road gutter northeast of the house shows what seems to be beach gravel of Early Lake Oshkosh overlain by red till. Elevation about 850 but this deposit may not have been made in a lake which was joined to that which discharged at Portage. 1 min to next.

148.6 Turn right onto town road.

148.8 STOP 9. View from Niagara escarpment over lowland floored by Galena dolomite. The Richmond shale is concealed by drift. Note the straight and regular outline of the escarpment. Martin ascribes this to glacial erosion. The fact that the fissured dolomite lay on soft slippery shale offered an optimum condition for glacial erosion. The Niagara escarpment was very important in directling the glacial lobes although the Green Bay Lobe on the west overrode it for some miles. The fact that so insignificant a feature affected lobation seems to show that continental glaciers were not ice rivers but oozed out along the margin where the slope sufficient to permit of gravitational flow was maintained during growth of the ice sheet at least by radiating winds which brought snow to the margin plus deposits from impinging cyclonic storms. This fundament difference from valley glaciers may well give us pause with regard to wholesale glacial erosion. 13 min. to next stop.

149.1 Edge of red till; gray drift beyond.

150.4 Turn left onto County Highway U.

152.6 Recessional moraine of Middle Wisconsin trending NE-SW.

154.0 Turn right (south) on town road.

155.3 STOP 10 5 min. The drumlins of this district trend both to SW and to S. The writer explains them as first formed by Early Wisconsin Lake Michigan lobe moving southwest. A movement of the source of ice to the west during Middle Wisconsin time caused the Green Bay Lobe to occupy the same district moving south to east of south. This reshaped many of the drumlins by a process in part erosion but mainly deposition. Drumlin east of stop has new tail built on. Important light is thus thrown on origin of drumlins and glacial erosion shown to be slight.

155.8 Turn right on town road. (10 min to next stop)

156.4 Turn left on town road.

157.9 Turn left onto AA. Follow AA around curve to right.

159.7 STOP 11 On crest of overridden drumlin. 10 min. Further discussion of overridden drumlins. Lake Michigan part should have only Niagara pebbles

160.0 Turn left onto Wis. 23 and continue east. Cross several isolated patches of morainal drift. 35 min. to end of run.

171.1 Greenbush (detailed log ends) East of Greenbush we cross the famous Interlobate Moraine. Two different views of its origin have been held. The early geologists held it to be two opposed terminals formed by the respective lobes. Later students have thought of it as made in the reentrant angle between the lobes and not all at once. This later interpretation explains the gaps. Glacial drainage was confined between the lobes and thus the stony till was largely reworked into assorted deposits chiefly gravel. Buried ice masses later melted to make kettles. As the angle widened out the older deposits were terraced for the most part before the isolated ice masses had all melted. East of the summit several such terrace levels and an abandoned drainage channel are well shown.

177.1 Plymouth. Night at Curtiss Hotel.

August 5, 1933

0.0 Leave Plymouth on Wis. 23 retracing route taken yesterday.

2.0 Turn right onto County Highway P and soon ascend Interlobate.

4.5 STOP 1 Gravel Pit of Moraine Sand and Gravel Co. Note foreset bedding. Mullet River here crosses through a gap. 10 min. from start. Stop 10 min. Continue on P under R. R. 5 min to next stop.

4.7 Pick up County Highway A and turn north on it.

5.3 Turn right with A.

5.5 Good view of moraine on left.

5.9 Turn left with A and make STOP 2 at top of grade. 5 min. View of Crystal Lake in kettle of pitted gravel terrace. 20 min to next stop.

7.0 Keep on A.

8.7 Elkhart Lake. Turn right at R. R. station heading east on A.

9.2 Pitted outwash well developed

10.2 Leave pitted outwash and enter till of Lake Michigan Lobe.

12.5 Thin edge of Late Wisconsin red till. No endmoraine.

13.8 STOP 3 Franklin gravel pit. Middle Wisconsin morainal gravel, overlain by gray till in turn buried by red till. 15 min. 40 min to next stop.

14.5 Turn right on A Red till ground moraine.

18.5 Turn right on A into village.

18.8 Turn left and cross Highway 32.

19.8 Turn right (east) on A.

21.5 Morainal topography to north possibly inherited from buried Middle Wisconsin terminal.

22.8 Turn left onto U. S. 141.

28.0 CAUTION: SLOW and close up for left turn at stop ahead.

28.7 Turn left into gravel pit south of Fisher Creek. STOP 4 15 min. Gravel underlying red till shows in part the assortment which is characteristic of beach deposits. May be Glenwood or pre-Glenwood beach of Early Lake Chicago formed during recession of Middle Wisconsin. Continue north on 141 into Manitowoc. 50 min. to next stop.

43.7 Turn left onto 21st. Street and go north across river.

45.0 Turn right (east) onto New York Ave.

45.7 Turn left (north) onto Wis. 42.

46.2 Turn right on 42 soon reaching shore of Lake Michigan. Much of the route to Two Rivers is along sandy beach with dunes.

51.0 Two Rivers continue on 42. Traffic lights.

52.1 Turn right on 42 on 22nd St. New bridge. Continue east on 22nd.

52.8 STOP 5 New Ball Park. 5 min. 17 ft. beach of Lake Algonquin. Cut in bank in spring of 1933 showed red till overlying older silt and lake sand/ Continue ahead on town road, 30 min to next stop. Route follows barrier beach of Lake Nipissing (24 ft.).

54.7 Turn left just south of creek soon crossing line of sand dunes.

56.1 Turn right onto Wis. 42 and continue north over red till ground moraine. Flat topography partly due to older lake deposits below.

64.5 Turn right at Two Creeks onto town road.

65.4 Keep straight ahead down lane to lake shore. Park cars and walk south along beach. Note intercision of creek. 1 hour stop. The best exposures of the Forest Bed are nearly a half mile south. Some digging may be needed. STOP 6. 20 min to lunch stop.

66.5 Proceed back to 42 and turn south to Two Rivers. lunch at Hotel Hamilton. Continue on 42, 13 min run back to Manitowoc.

82.9 STOP 7. Gravel pits. Upper layers disturbed by ice but no red till. Later lake deposits unconformable above. 30 min. 10 min to next stop. Continue south on 42 into Manitowoc.

83.5 Turn right onto New York Ave.

84.2 Turn left and cross bridge and lowland.

85.0 Turn right into trail to clay pit.

85.8 STOP 8. Pit of Medusa Portland Cement Co. Permission to visit at own risk secured by F. T. Thwaites from Cleveland office. 25 min. Red till overlying varved clays (disturbed by shove) which lie on gray till. Return to 21st. St. and go south. 30 min to next stop.

86.3 Turn right onto Washington Ave., Wisconsin 31. Follow 31

89.5 Red till moraine

92.4 Red till over gray till in road cut showing that topography is inherited.

97.4 Morainal topography, gray till shows in places.

100.6 Turn right (north) onto Wis. 141. Continue north up rock hill.

100.9 Turn left just north of house on left.

101.4 STOP 9. 20 min. Crossing striae on Niagara dolomite. Roshaped drumlins. The Late Wisconsin ice which reached this locality must have crossed the Door County peninsula and then spread out westward over the lowland east of the Interlobate Moraine. 15 min to next stop. Return to 31.

102.1 Rejoin 31 and go southwest.

107.3 Entering interlobate moraine partly overridden by red till.

108.3 STOP 10. 5 min. See interlobate moraine. There is a gap to north. Beyond that the interlobate is all buried by red till. It stops in Kewaunee County about 30 miles to north. 45 min to next stop.

109.4 Note conical moulin kame on left, the first seen.

110.5 Turn left (south) onto Wisconsin 32. Leave Late Wisconsin drift.

118.2 Turn right with 32

118.6 Turn left with 32 across bridge. Kiel.

119.1 Turn right onto Wis. 57.

121.4 Extremely pitted topography of Interlobate.

124.6 Elkhart Lake. Turn right onto County Highway A. Retrace out route to

131.5 Greenbush. Turn left on Wis. 23.

131.7 Turn right onto County Highway A.

132.5 STOP 11. Ice contact face of Interlobate without till, suggesting temporary stagnation of ice. Continue on A. 5 min to next stop. 5 min.

133.4 STOP 12. Large kettle in summit of interlobate which is here a terrace. 10 min. To southwest is a moulin kame which must be older, possibly formed some distance back from ice margin. 15 min. to next stop.

133.7 Well marked terracing.

134.1 Kame with flat top on right.

134.6 Descend to a lower terrace.

135.2 Well-marked outwash terrace. Turn right onto Wis. 67 (paved).

136.2 Branches of interlobate both right and left.

138.7 Turn left onto County Highway V. From here south pass through a group of moulin kames.

140.0 STOP 13 10 min to see kames. 40 min to next stop.

141.2 Turn left on V, McMullin Hill.

142.1 Cut in crevasse filling, turn left following V

143.7 Parnell, turn right onto A.

144.6 Turn right with A.

145.1 Turn left with A.

146.6 Turn right with A.

147.1 Left with A.
149.5 Right with A. Beechwood.
151.8 Right on S. County line.
154.1 Left with S.
156.0 Turn right
156.6 STOP 14. 10 min. Cut in moulin (?) kame showing forcset bedding. 20 min to end of day.
157.6 Turn left on S.
159.6 Moulin kame on left illustrated by Aldon.
159.8 Turn right onto Wis. 28 at Kewaskum.
160.2 Turn left into Wis. 55. Go south.
167.5 West Bond, Hotel Goib.

August 6, 1933
0.0 Go north on 55 to Barton retracing yesterday's route. 10 min to stop.
1.2 Barton, turn left into town road.
2.6 STOP 1 Pit of Northern Gravel Co. 25 min. Park cars off road and climb to top of strip dump. Forcset or slumped bedding. Return to cars and go on west through some very striking topography. 12 min. to next stop.
3.3 Turn left on town road.
4.1 Turn left onto County Highway B.
5.0 Turn right onto Wis. 33.
7.3 Turn left onto J. STOP 2, 10 min. to see glacial drainage channel, outwash terraces, and till interlobate to west. 5 min. to next stop.
10.1 STOP 3 5 min. Crevasse fillings to left including island. 15 min. to next stop.
14.9 Turn right onto Wis. 60. Interlobate here is nearly all gravel.
15.9 Turn left into town road. When fresh cuts showed gravel despite numerous boulders.
16.7 STOP 4. Sugar Loaf Hill, also known by other names. 15 min. Pit shows faulting in horizontally stratified sand and gravel. Apparently a moulin kame. Continue on town road. 15 min to next stop.
17.9 Turn right onto County Highway E.. Descend ice contact face of interlobate. Gravel and till much mixed.
18.4 Turn left onto K. Ascend gradually to top of moraine. Crevasse fillings to right suggest stagnant ice. Holy Hill soon seen to left.
23.5 STOP 5 5 min. to view Holy Hill from top of till interlobate. 20 min to next stop.
25.7 Sharp right turn up steep hill in bouldery gravel. Glacial drainage channel to left (Oconomowoc River) Here drainage from the Lake Michigan Lobe crossed the line of the Interlobate into Green Bay territory. There is no real Interlobate for several miles south of here.
25.9 Turn left on terrace.
26.2 Turn right
26.7 Turn left
27.0 Turn right and follow winding road through pitted outwash to
28.2 Turn left into Wis. 83. Follow 83 through North Lake, where there is a large gravel pit in end of terrace across pitted plain with till knoll.
31.3 STOP 6 5 min. Junction 83 and K. Much pitted outwash in golf links. Turn right onto K. 20 min to next stop.
33.2 Turn left onto County Highway C. Follow crevasse filling between Mouse and Okauchee Lakes. Pitted outwash with some till knolls?
39.2 Delafield, turn left onto Wis. 30. Hill to south formerly called Government Hill. Now the name Lapham Peak (after Lapham who lived near here) has been placed on this hill having been displaced by name Holy Hill where first applied.
40.4 STOP 7 Park cars at right and climb onto interurban track. Terraces along side of Lake Nagawicka show that ice block reached surfa

10 min. 5 min. to next stop.

41.0 Turn right onto Wis. 83.

41.2 Park cars in gravel pit at left. STOP 8 15 min. Climb to top of pit to view glacial drainage outlets. At first water from Lake Michigan Lobe discharged to south. When ice block in Lake Nagawicka melted enough outlet changed to west for here the Green Bay ice melted first. This gave higher gradient and beheaded old channel. Lake Nagawickaice block lasted until drainage had ceased. 5 min to next stop.

43.4 STOP 9 View of outwash terraces near Statesan. The number of such terraces is legion. As the ice reentrant broadened successively lower and lower outlets became available. 35 min to next stop.

44.0 Turn right onto U. S. 18 and go west past old R. R. gravel pit in very bouldery gravel.

44.7 Drainage outlet previously seen. At first this discharged to south but later to west along Scuppernong Creek.

45.4 Drainage outlet.

46.2 Terrace edge.

47.8 Same

48.2 Turn right onto Wis. 67. Go north on lowest outwash plain past several lakes in kettles.

51.2 Turn left onto Wis. 30.

53.0 Island of terminal moraine rising through outwash.

57.0 Last of outwash. Enter drumlin area.

60.7 STOP 10. Eskor between drumlins. 5 min. 10 min to next stop.

63.2 Turn left onto County Highway D and go south.

66.7 STOP 11 5 min to see drumlin topography. 10 min to next stop.

67.7 Turn left on U. S. 18. Continue east through fine drumlins and cross bridge over R. R. SLOW, sharp turn ahead.

70.0 Turn right and recross R. R. at grade. DANGER.

70.6 Pick up County Highway P and turn left.

70.9 STOP 12 2 min. Fine drumlins. 12 min to next stop.

72.5 Rome, Turn right into Wis. 90 and then left at west end of village.

77.1 STOP 13 on top of drumlin to see Interlobate Moraine face to southeast across Scuppernong Marsh. 5 min. 25 min to next stop.

81.8 Palmyra. Turn left onto Wis. 59. Continue northeast at foot of Interlobate.

86.1 Enter Interlobate.

87.5 Top of Interlobate. Highest or No. 1 terrace to east.

87.8 Turn off to right on gravel road, cross R. R. and pick up Wis. 99 on main street of Eagle. Continue east. Lunch stop here to be arranged.

88.9 Second terrace due to cutting away of glacial drainage outlet.

89.7 Turn right onto County Highway NN.

90.2 STOP 14. Discussion of terraces. 10 min. 15 min to next stop. The second gravel terrace was formed when new low drainage outlets, in part via Sugar Creek were opened to the south and drainage to the west was abandoned. It must be realized that stagnant ice masses were just as effective in this regard as living glaciers. All the terracing was accomplished rapidly before the ice blocks all melted.

90.9 Turn right.

93.4 Pick up Wis. 67 straight ahead.

98.7 STOP 15 5 min. 3 min to next stop. Recessional of Lake Michigan Lobe rises through outwash. Along this front the Lake Michigan (Delavan) ice retreated first and its territory was filled by outwash from the Green Bay ice. Continue ahead onto U. S. 12.

99.6 Turn right onto town road.

100.0 STOP 16. Walk into private road to left to top of hill. Fine view over pitted outwash plains with lakes from top of recessional moraine. 5 min. 15 min to next stop. Route over Heart Prairie which is an older terrace than that at Eagle.

102.1 Bird School. Turn right, North, onto County Highway H.

102.7 Turn left onto town road.

105.9 STOP 17. 5 min. Inside edge of Elkhorn Moraine where it joins the Interlobate. Old R. R. cut. 2 min to next stop. TURN RIGHT(north).

106.7 STOP 18. 30 min. Old R. R. cut through very stony till of Interlobate. Note that ground moraine on Green Bay side is much lower than Heart Prairie. 20 min to next stop.

107.2 Turn left onto County Highway P. Good view of cut just left.

110.0 Turn right onto town road.(west) Going west cross interlobate proper and enter on pitted plain between Johnstown and Milton Moraines.

114.0 STOP 19. 5 min. 5 min to next stop. Here see relation of Johnstown or endmoraine of Green Bay Lobe and Milton or first recessional.
Turn left (south) onto Wis. 89.
Going south cross Johnstown Moraine.

116.5 Go straight ahead leaving pavement.

116.8 STOP 20 at church. 5 min. 20 min to next stop. View of reentrant angle between Johnstown and Darien Moraines. In Aldon's reports the latter is regarded as the end moraine of a separate lobe, the Delavan, but present day mapping shows that this lobe was only a minor excrescence on the side of the Lake Michigan Lobe.
Turn left and go through village of Richmond to rejoin 89. Follow 89 along border of Darien Moraine. Outwash to right somewhat eroded by glacial waters during ice recession from the Darien.

121.7 Turn left onto Wis. 20. Cross Darien Moraine and come into Turtle Creek drainage outlet. At crossing of creek note gravel pit to left on slip off slope of curve.

123.7 Turn right onto town road on outwash terrace. This outlet was used during the formation of the two highest gravel terraces at Eagle.

124.8 STOP 21. 10 min. 25 min to next stop. Gravel pit on left, now closed showed till of moraine resting on outwash. Good view of outlet.

126.7 Darien; right onto Wis. 14.

126.8 Left onto 89 at traffic light. From here 89 follows the edge of the moraine. To right outwash plain is found most of the distance. The low hills farther west are subdued drumlins of Illinoian age which trend southwest. They demonstrate a much greater extent of the Lake Michigan or Illinois lobe than occured later.

130.7 Turn left onto town road. Cross Darien moraine noting gray till.

134.0 Turn right onto Wis. 36 on ground moraine. Go south on 36.
CAUTION: steep grade down into Fontana with stop at bottom.

134.8 Turn right into gravel pit. STOP 22. 5 min to next stop. Ask permission at office. Ascend side of pit seeing section. Good view of Lake Geneva from top. History of lake involves a dual maximum of the Middle Wisconsin. First till is concealed. Recession to east of Elkhorn left ice mass in proglacial valley where lake now is. This was largely buried by outwash. Then readvance to Darien Moraine left till on top. Melting made much "false moraine" around the lake.
30 min. to stop here. Continue on 36.

137.2 After bad R. R. crossing (CAUTION), turn left on County Highway B.

138.7 Park cars east of overhead R. R. crossing and walk back for STOP 23.
This view shows the reason for the early misinterpretation of the souther extension of the Darien Moraine. Aldon shows it curving back into Wisconsin to the east and joining the Valparaiso Moraine which Leverett had mapped as the border of the Middle (Late) Wisconsin. Recent study has traced the West Chicago moraine northwesterly into the Darien crossing the older Marengo Moraine at a marked angle. The Darien-West Chicago is clearly an endmoraine of a substage as it is bordered by non-pitted outwash. It shows a marked westward shift of the center from which the ice came. This westward movement of source is marked from Illinoian time on and explains the changes in lobation for the lobe were mainly marginal features and the direction from which the ice approached local topographic features affected their shape. The change

also affected the color and nature of the tills. The Early Wisconsin till of Marengo Moraine is probably red because derived in part from the red beds at the base of the Niagara not far distant. The Darien till is gray and stony because it came from a different direction and the ice overrode outwash. The cause of the Late Wisconsin red till was discussed before. The westward progression of glacial activity is marked from the Illinoian to the Des Moines lobe. Exceptions are (a) the Iowan, if regarded as earliest Wisconsin, and (b) a Patrician readvance near Winnepeg which is later than the Keewatin advance. In Wisconsin, however, it seems to furnish a key by which the several Wisconsin substages can be separated. Reference should be made to the overridden drumlins near Fond du Lac. The new mapping, however, tends to minimize the Delavan glacial lobe. 20 min. stop. Turn cars around and go west to

139.7 Walworth. Night at Wayside Hotel north side of park.

August 7, 1933

0.0 Leave Walworth on Wis. 89 south over non-pitted outwash. The White Rock Moraine at the border of the Wisconsin drift has not been discriminated in Wisconsin nor have the age relations of this marginal drift to the Marengo Moraine been studied. The fact that the outwash between the two is not pitted has little significance because the upper part of this deposit is certainly derived from the younger Darien-West Chicago Moraine of Middle Wisconsin age.

2.5 Big Foot Prairie-Wisconsin-Illinois state line.

Here the writer turns over the discussion to the Illinois geologists. He wishes in closing to make it clear that the statements herein given are to be regarded in the light of suggestions. They were based on ideas gained on field trips with students and have not been checked by detailed study.

F. T. Thwaites

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Personal copy

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GLACIAL GEOLOGY OF THE CENTRAL STATES

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Note: On account of the uncertainty in regard to carrying out the trip all of the route was not logged. Several cars were used and the mileage readings have not all been corrected. Data on the parts not logged were taken from topographical and highway maps. Drivers should reset speedometers from time to time as no two such instruments ever check exactly. The writer is personally responsible for all statements and opinions herein expressed. See Guide Book for interpretations held by U. S. Geological Survey.

August 3, 1933

0.0 Junction U. S. 18 and Wis. 27 in Prairie du Chien. Turn right, south, on 18.
7 min. run over very level sandy outwash plain of Wisconsin glaciation. Bluffs to left 560 ft. high, capped with Galena dolomite.

3.4 Bridgeport terrace on left. See Guidebook. Enter valley eroded in terrace.

3.7 STOP 1 10 min. Park cars in side road to left. Cut shows pebbly sand of 125 ft. terrace (740 A. T.) banked against side of Lower Magnesian dolomite bluff. This material in which the bedding dips east is probably a slack water deposit on downstream side of rock hill. It may be much younger than the highest or 190 ft. terrace. Proceed either on foot or in cars to visit new cuts in high terrace along U. S. 18. Shovel will be needed.

4.9 STOP 2 20 min. Discussion of Bridgeport terrace hypotheses. (a) Till of Kewatin glacier, (b) outwash from Kewatin glacier, (c) outwash down Wisconsin River at time when rock bottom was higher than at present. Under last hypothesis all traces of this level have been destroyed upstream where bed rock is sandstone instead of dolomite as it is here. An erosion interval then followed and the terrace was dissected before the 100-125 foot filling was deposited. These terraces were in turn eroded before the earliest Wisconsin glaciation. Attention should be directed to character of the pebbles and to direction of dip of foreset bedding. 30 min. run to next stop.

5.9 Junction with Wis. 60. Keep left on 60.

10.0 Leave Bridgeport terrace. The writer interprets several of the valleys in the terrace as superimposed on an older rock topography as a result of valley filling.

17.0 Wauzeka. Cars will leave main highway to pass gravel pits in old terrace deposits. STOP 3 here or on ridge 1 mile above. 15 min.

19.0 Mouth of Kickapoo Valley. Note "underfit" stream in small meanders on floodplain within huge entrenched or ingrown bends. Higher up the valley some such bends have been cut off probably as result of pre-Wisconsin valley filling. Such phenomena do not prove decreased volume of the Kickapoo but rather the change in conditions due to alluvial fill in response to blocking of outlet by glacial outwash.

20.0 STOP 4 Gravel pit at Porter School 20 min. This pit is in what the writer interprets as a terrace younger than the highest Bridgeport terrace. It is 75 to 100 feet above the river and moderately eroded. 15 min. run to next stop.

27.0 Bridgeport bridgehead. STOP 5 Climb Easter Rock 350 ft. high for discussion of terrace problem and physiography of Wisconsin Valley, 30 min. stop. 1 hr. 20 min. run to next stop.
Turn right onto U. S. 61 and cross terrace of Wisconsin River at Boscobel. Two Wisconsin terraces are present. The lower one is 12 to 15 ft. above the floodplain and was eroded from the higher terrace by the waters

from Glacial Lakes Oshkosh during the retreat of the Middle Wisconsin and during Late Wisconsin time. The higher terrace was deposited during the formation of the Middle Wisconsin.
Continuing south from Boscobel on 61 we ascend the course of Crooked Creek. As in all other tributaries which head in the Driftless Area, this valley was aggraded to most in part at least the filling of outwash in the main stream which carried glacial drainage. Meandering on such fill has led to the formation of rapids and falls wherever the stream found itself superimposed on rock spurs when erosion of the filling permitted entrenchment.
The stratigraphic column south of Boscobel includes in ascending order the highly glauconitic Franconia sandstone (Cambrian), the yellow and red dolomitic siltstone and gray fine grained sandstone of the Trempealeau formation (Cambrian), whose top was formerly called Jordan, the gray dolomites of the Lower Magnesian group (Oneota and Shakopee, Ordovician), the soft but crag-making St. Peter sandstone (Ordovician), the Platteville dolomite and limestone (Ordovician), and the Galena dolomite (Ordovician),

41.0 Fennimore. Turn left with U. S. 18. From here east the route follows the famous Military Ridge which is the crest of the Galena-Platteville Cuesta. The country is more rolling than is apparent to the eye, for the subequal elevation of the ridges blends in the distance into the semblance of a plain. This "plain" constantly retreats from the observer like a "will-o-the wisp". As a matter of fact the upland is typical "dolomite topography." Note scarcity of sink holes. The steep-sided valleys occur only where erosion has cut through to the sandstones. Early geologists assumed that this upland was a remnant of a peneplain and that the same surface extended to the north beveling across the older formations. It is known, now that topographic maps have been made, that such is another illusion. There is really a marked series of dissected cuestas whose escarpments ring around the pre-Cambrian highland of northern Wisconsin. Similar uplands occur also on the Niagaran of Illinois and Iowa, the Lower Magnesian of Wisconsin and Minnesota, the Franconia sandstone in Wisconsin, and some of the shale horizons in the Eau Claire formation (Cambrian) of Wisconsin.
An important factor in their formation is the presence of clay or shale which acts as a roof in protecting the underlying rocks from weathering. The uplands on the dolomites bevel the formations to a slight degree, but this is a normal effect from the fact that the crests of the cuestas have been exposed to the weather much longer than have the vales where the overlying formation has been but recently removed. To ascribe every upland to former peneplanation requires too many peneplains each too closely controlled by geology to be credible. Besides, the same bench effect is noted within valleys wherever such cut down to the proper geologic horizon.
68.0 Dodgeville. Turn right and stop at Hotel Higbee for lunch. 45 min.
Return to U. S. 18 and go east. 40 min. run to next stop.
86.0 Dane County line - detailed log begins.
86.5 Blue Mound. Turn left under R. R. on County Highway F.
87.0 Turn left up hill on F.
87.3 STOP 6 at entrance to Ball Park. 15 min.
Thence continue north on F.
87.8 STOP 7. 15 min. Discussion of peneplain problem. The view from here displays the reason for the early misconception of an all-embracing upland peneplain as the escarpment caused by the St. Peter sandstone (whose thickness varies greatly) is invisible from behind. Trowbridge abandoned this idea in favor of two peneplain levels. Of these the older (Dodgeville) accounts for the crests of the cuestas and for the level upland of the Baraboo Range (Huronian quartzite) which can be

soon from here. The lower surface (Lancaster) lies roughly 200 feet below and accounts for the upland on the Lower Magnesian north of here. It also occurs on the bluffs along Mississippi River and in the vale south of Military Ridge cuesta. Trowbridge regards the ridge north-east of Prairie du Chien between Mississippi and Kickapoo rivers as a "bridge" between the Dodgeville peneplain on the cuesta of Military Ridge and on the Magnesian cuesta to the north. Although recognizing the possibility of this explanation the writer begs to ask some questions: (a) How is it that there is no difference in degree of dissection of the Lancaster and Dodgeville surfaces?, (b) How is it that at all points rock control is the dominant factor and is capable of explaining all the facts?, (c) How is it that one finds exactly the same type of topography down the back slope of every cuesta making a transition between the two upland surfaces?, (d) Why should an uneroded remnant of the higher surface be left between two of the largest streams rather than far from streams?, and (e) How can the upland of the Baraboo Range be fitted into the picture? It may be added that the "topographic unconformity" between the upland and valley sides is everywhere capable of explaination by rock control and that the upland gravels and the rare ingrown bends do not in themselves prove much. Turn cars around and return south on F. 30 min to next stop.

88.5 Turn left on town road.
88.6 Sink hole on right
89.2 Rejoin U. S. 18, keep ahead on 18.
100.2 St. Peter escarpment poorly developed as sandstone is thin here.
100.9 Terminal moraine ahead on skyline.
103.0 STOP 8. 10 min. Park cars just east of R. R. clear of pavement. Walk back and up track to see post-Illinoian rock gorge due to diversion of stream by Illinoian terminal moraine. Turn back to cars and continue on 18. 7 min. to next stop.
103.2 Illinoian terminal to left indistinguishable from rock hills.
103.5 Cut in old drift overlying disintegrated Lower Magnesian dolomite. DRIVE SLOW to see boulders in residium.
104.0 Johnstown Moraine east of stream. Continue on 18 to
104.8 Verona, there turn right onto Wis. 69 south on main street.
105.2 Turn half right with 69.
105.8 STOP 9 to see gravel pit in outwash just outside moraine of Middle Wisconsin. 10 min. 8 min to next stop. Turn cars around and retrace way out going west on 18 to edge of terminal.
107.6 Turn right into town road.
108.4 STOP 10 10 min. On crest of Johnstown Moraine. Unglaciated or possibly old drift covered hill across ravine cut by marginal drainage. 10 min to next stop.
108.9 Turn left leaving terminal moraine. Loess-covered outwash terrace eroded by waters from east of endmoraine.
109.8 Turn left (west).
110.0 Turn right on outwash terrace soon reaching foot of terminal moraine.
111.1 STOP 11. 5 min. Drainage outlet through Johnstown Moraine. Continue ahead, 15 min to next stop.
111.7 Turn left. CAUTION: use second speed descending hill.
112.3 Turn right. St. Peter outcrop. This country unglaciated.
113.3 Turn right and immediately left. Road relocated since map.
114.5 STOP 12. 10 min. 3 min to next stop. Depression enclosed by endmoraine.
115.1 CAUTION: cross main road, keep ahead.
115.2 STOP 13 To see underground outlet from depression. 3 min. 6 min. to next stop.
117.0 STOP 14. Cut in terminal moraine which here bends west into valley to north. Very bouldery till. 5 min. Turn right (north). CAUTION: use second speed on steep descent. 10 min to next stop. Continue to Wis. 11.
118.0 Turn left onto 11 and go west crossing low endmoraine (Johnstown).

119.5 Turn left into side road. STOP 15. 15 min. 35 min to end of day's run. From this point the contrast between the craggy hills of the Driftless Area and the smooth rock hills of the glaciated area is most striking. The endmoraine itself is, however, not very conspicuous as it is covered by outwash and eroded by drainage from farther east. Note boulder concentrate along the stream caused by waters from second or Milton Moraine. 2/10th mile down this road is a gravel pit in the outwash. For many years the Driftless Area has been held up to students as an example of what the adjacent glaciated country looked like before glaciation. It is necessary to realize that not all of the glaciated country originally had as rough topography as here. From East Blue Mound the contrast between the very dissected country north of Military Ridge and the dolomite uplands to the south is very clear. We must also distinguish between preglacial and pre-Wisconsin. Assuredly much erosion went on in the Driftless Area during the Pleistocene. However, most geologists do not agree with Trowbridge in thinking that the "Lancaster peneplain" was dissected almost entirely since Nebraskan time. Many years ago Chamberlin and Salisbury tried to measure the importance of glacial erosion in smoothing the glaciated area by comparing the average depth of residium in the Driftless Area with the average depth of drift in the glaciated district. Although they seem to have underestimated the former the fact that much of the drift clearly was derived from comparatively fresh bed rock is conclusive evidence in favor of glacial removal of crags, ledges, and small hills. This fact is here demonstrated. On the other hand, the writer has always been conservative in accepting glacial erosion of large basins as at Madison or in the Great Lakes. Continental glaciers lacked the sloping basement of mountain glaciers. They were not ice rivers and active flow must have been confined to a marginal belt of possibly 150 miles. This belt of moving ice migrated outward during glacial expansion. The main advantage of a glacier over a stream in erosion is the plucking of large masses of broken bed rock. Abrasion must have been unimportant. Over much of the glaciated area considerable decomposed rock is left and the forms of the hills are not related to direction of ice movement. Turn cars around and return to 11.

rock

119.9 Turn right onto 11 and retrace route for some distance. Keep on 11.

121.0 Narrow place in valley is preglacial divide between Wisconsin and Rock basins. Glacial deposition moved the divide to east of Middleton.

122.5 Marked recessional moraine, part of Milton system. Ice must have still been moving to make this moraine. East of here valley is occupied by pitted outwash for several miles.

124.5 Ice contact face. Flat on left was site of postglacial Extinct Lake Middleton. (See again tomorrow.)

125.4 Middleton. East shore of lake. Pick up U. S. 12 and keep ahead.

126.2 Curve right with 12. Outer edge of main part of Milton Moraine.

127.3 Turn left off 12 on paved road. From here follow lake shore drive. Most of the hills are made of rock much of which is deeply weathered. This makes extensive glacial erosion of solid rock improbable. Maximum depth of drift near Madison 372 feet below lake level. Maximum depth of lakes 80 ft. Hills at the University are composed of sand and silt with some till on side toward lake. Appear to be a slumped or shoved deltaic moraine deposited when ice had shrunk into lake basins and may have become stagnant. Several hills in the city are perfect drumlins.

132.0 Night stop at University Club on State St.

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0.0 Corner of Park and University in Madison. Keep west on U. S. 12.
7.1 Turn right (north) in Middleton. 50 min. to first stop.
7.6 Cross Pheasant Branch. Postglacial stream piracy has drained Extinct Lake Middleton into Lake Mendota. Former outlet was to west to Wisconsin River. This process would in time restore the preglacial divide. Beyond the lake basin country is thinly drift-covered rock hills.
13.8 Pitted outwash plain in valley.
15.1 Gravel knolls of a higher outwash terrace or kame terrace.
17.1 Divide between Yahara and Wisconsin drainage. Note kettles on hill top. In such rough country the ice probably stagnated soon after reaching its maximum. It is difficult to trace any continuous moraines. In clear weather Blue Mounds may be seen on left.
18.9 Pitted outwash in valley. Some morainal deposits occur along the sides but rock control is dominant.
23.5 Gravel pit on left was used for paving U. S. 12.
23.8 Valley eroded in outwash by outlet of lakes to east.
24.2 Part of Johnstown moraine to right projecting above outwash which is here cut up by postglacial gullies.
24.8 Descend from high outwash terrace to Wisconsin River.
25.1 Wisconsin River. Note the sand bars.
25.4 Turn right at traffic light. (U. S. 12)
26.5 STOP 1. 3 min. View of terminal moraine across River, eroded outwash terraces, and unglaciated hills (Round Bluff and Blackhawk Bluff). 7 min. to next stop.
27.7 Ascend from terrace to high outwash level.
28.6 Turn right into private drive to dam of Wisconsin Power and Light Co. Johnstown moraine here crosses Wisconsin River and may be seen to left.
28.9 STOP 2 Park cars on gravel and walk to edge of bluff. Opposite is Blackhawk Bluff which was a nunatak at maximum of Middle Wisconsin. Descend stairs and see to right till of Johnstown Moraine overlying outwash. CAUTION, do not leave the stairs as slope has been planted to grass to check erosion. By going down the stairs and turning right at the plant an exposure of outwash may be seen in new pit. Weidman held that this exposure of outwash under the moraine demonstrated that the terraces are of pre-Wisconsin age. MacClintock showed the error of this view. The dam is founded on sand and it has been a serious problem to prevent erosion from undermining it. 20 min. stop.
Return to cars. 8 min to next stop.
29.3 Rejoin 12 and turn right. Follow 12.
31.6 Drainage outlet through moraine and stream channel in outwash well seen.
32.5 Turn left into town road.
32.9 Turn right at school house.
33.2 STOP 3. 5 min. Kettle in outwash with pond perched on silt. Note well drilled for late ex-Governor Phillip on west side. This well disclosed a layer of till below the outwash. This demonstrates a dual maximum of the Middle Wisconsin. At the first advance the ice locally went farther west than it did when the Johnstown Moraine was deposited. A block of ice was left here on retreat of the ice front. It was buried by outwash. The ice front retired several miles and the outwash seen at the dam was laid down. A readvance then resulted in the balance of movement and wastage which formed the Johnstown Moraine. The moraine of the earlier maximum is probably the Brooklyn Moraine which occurs south of Madison and was formerly correlated as probably Early Wisconsin. 5 min to next stop.
33.7 Rejoin 12. Keep ahead.
35.6 Turn right onto County Highway Z. STOP 4. 3 min. To north there is an alluvial fan at foot of Baraboo Bluffs of Huronian quartzite. The fan has been dissected and is covered with loess as is much of the

outwash. Similar gravels to those of the fan occur farther west and are known to be of pre-Wisconsin age.. 15 min. to next stop.

136.4 Pine Hollow on left, youthful gorge in quartzite in bottom of hanging valley. Cause of hanging doubtful, possibly cliff cutting of Cambrian sea.

37.0 Turn left. CAUTION: steep hill ahead, use gears.

40.4 STOP 4 35 min. Park cars close to right bank and walk to top of West Bluff overlooking Devils Lake. From this point the moraine can be seen at both ends of the Lake. History: (a) pre-Cambrian sedimentation, (b) pre-Cambrian mountain making, (c) pre-Cambrian peneplaination leaving quartzite as monadnocks and forming wide mature valleys in the bluffs such as that west of the Bluff, (d) Cambrian to Silurian sedimentation concealing quartzite entirely.(Blue Mound 1716 ft. here 1460.), (e) erosion by superimposed streams exhumed much of older topography and made new gorges with cliffy sides; gorge then 900 ft. deep, now 500, (f) early Pleistocene outwash filled gorge to about 100 feet below lake level, (g) Middle Wisconsin glacier split by bluffs to east closing in lake basin; water in lake one higher covering plains at both ends but no definite outflow channel known unless along ice front to northwest, (h) ice retired from northern part of moraine allowing waters to erode channel now followed by railway and reach level of Glacial Lake Baraboo, about 980, (i) present conditions. The level tops of the bluffs are parts of an extensive plain which vaires from 1400 to 1500 feet elevation. Due to either (a) stream erosion or (b) marine planation during Paleozoic sedimentation. Time of formation either (a) pre-Cambrian subaerial peneplain, (b) Paleozoic marine plain, or (c) post-Paleozoic subaerial peneplain during removal of sediments. The writer favors marine theory because of (a) extreme flattness, (b) presence of coarse boulder conglomerate off edges of summit flats, (c) presence of residium of Paleozoic formations on upland. The famous potholes on East Bluff were formed after deposition of Paleozoic sediments and before they were eroded away. The pre-Cambrian drainage at the lake was probably to north. Later a superimposed stream (Wisconsin River) widened and deepened this valley as shown by hanging valleys southeast of the lake. Return to cars. 30 min to next stop.

41.1 Terminal moraine corsses road and continues to northwest.

41.3 Join Wis. 123 (paved)

41.4 Turn left off 123 onto Wis. 159 and go west across terminal. From terminal can see in same view (a) terminal, (b) deltaic outwash plain, (c) pre-Cambrian mature topography on quartzite (exhumed), (d) gorge due to superimposed stream, (e) upland peneplain.

42.7 Join U. S. 12 and turn right (north). Unglaciated rock ridge to west. Continue north over delta deposited by glacial streams in edge of Glacial Lake Baraboo.

43.9 Top of terminal moraine.

44.1 Leave 12 by keeping straight ahead down steep hill. CAUTION: dangerous R. R. crossing over main line of Chicago and Northwestern.

45.3 Rejoin 12 and keep straight ahead. Terminal moraine to left and ahead.

45.9 Top of terminal. Eroded edge of delta ahead.

51.8 Edge of delta whose top marks level of Glacial Lake Wisconsin in valley of Wisconsin River. Outlet to East Fork of Black River.

52.5 High hill to left has glacial pebbles on top above level of lake. Origin?

53.8 Artificial lake in post-Wisconsin gorge of Doll Creek.

54.1 Dolton. Turn right with 12. Postglacial gorges. Farther on pass into preglacial topography in Eau Claire sandstone (Cambrian). Top of Eau Claire is marked bench caused by thin layer of shale.

56.2 STOP 5. Park cars at right under trees and walk to old clay pit. 10 min. to see varved clays of Glacial Lake Wisconsin. 5 min to next stop.

56.9 Turn right onto U. S. 16. Cross river and keep to left onto main street of Wisconsin Dells or Kilbourn.

57.6 Traffic light. Character of stop at the Dells is not settled. The full boat trip takes over two hours. The Dells owe their origin to the diversion of Wisconsin River by the Johnstown Moraine to the east. Preglacial course lay east of moraine. Here the river was superimposed on a spur of Eau Claire sandstone. Erosion has produced many striking scenic features especially where the sandstone is cross bedded but the geologic and physiographic features are by no means as varied as at Devils Lake. Continue east on U. S. 16, from STOP 6. 15 min to next.

58.1 Turn right with 16. Eroded deltaic outwash.

59.6 Gravel pit.

59.9 Top of Johnstown Moraine.

63.9 Leave terminal moraine and enter big swamp. As the ice front melted back from the Johnstown Moraine the level of Lake Wisconsin was maintained until the east end of the Baraboo quartzite bluffs was cleared. Then the waters fell to the level fixed by the top of the rock spur at the Dells. Erosion of this destroyed the last remenant of Lake Wisconsin and east of the moraine another body of water, Glacial Lake Oshkosh came into existance. This had its outlet where Wisconsin River crosses the moraines above Prairie du Sac.

65.7 STOP 7. 5 min. Foreset bedding in deltaic moraine deposited in glacial lake. The regular shape of this moraine (Milton?) suggests that the glacier was moving at time of formation. 20 min. to next.

66.8 Another deltaic moraine.

75.7 Pitted outwash plain at Portage indicates that level of Glacial Lake Oshkosh in Fox and Wolf valleys to north never exceeded this level of about 830 ft. Higher beaches are known to the north but the extent to which they have been deformed by postglacial earth movement and the extent to which they are the deposits of local lakes shut in by an irregular ice margin has not been determined. After the retreat of the Middle Wisconsin ice Lake Oshkosh ceased to exist. It was brought back again by the readvance of the Late Wisconsin. The beaches of this later lake have almost certainly not been deformed.

77.2 Portage. Route from here to Waupun not logged. Lunch at Hotel Raulf For several miles east of Portage the route is over a pitted outwash plain apparently formed by drainage from isolated stagnant ice masses left in valleys to the east during the recession of the Middle Wisconsin. The paucity of moraines formed of till and therefore the product of moving ice strongly suggests that intervals of stagnation affected the ice sheet at least toward its edges. Such a condition could be brought about by lack of snowfall. Then the edge of the icesheet would flow out until equilibrium was reached. Movement might be reinstated either by increased precipitation or by melting back of the margin to a steeper slope. About 1 hr. 45 min. to next stop. Highway 33 to Fox Lake.

107.0 Cross Green Lake Moraine.

108.0 Fox Lake. Leave 33 and pick up Wis. 68.

119.0 Waupun. Pick up U. S. 151, straight ahead.
Between Waupun and Fond du Lac the route crosses the Waupun, Rush Lake, and St. Anna Moraines, an important group of recessionals which are probably the product of a readvance of the Green Bay Lobe.

125.5 Esker on right

128.2 Note Niagara escarpment on right.

130.2 Lamartine. Outcrop of Galena dolomite instream bed. Ridge to east is St. Anna Moraine.

134.3 Morainal ridge at border of red drift or Late Wisconsin. The red till probably mantles a ridge of the Middle Wisconsin gray till. The color which is so characteristic of the Late Wisconsin in this district is due to two factors: (a) during the recession red clays colored by drainage from the iron ranges of northern Michigan were deposited to be later

plowed up by the ice making a very clayey till, and (b) the Late Wisconsin ice in this region came from the Patrician center and thus passed directly across some of the iron ranges. South of this ridge a glacial lake discharged to Rock River through Horicon Marsh which was then a lake.

137.5 Fond du Lac-traffic light. Turn left and then turn right at next corner onto County Highway T. We are now in bed of Lake Oshkosh.

140.4 Turn left (north) onto County Highway K.

141.0 STOP 7. 10 min. Gravel pit showing marginal deposits of Middle Wisconsin overlain by red clay of Later Glacial Lake Oshkosh and thin red till of Late Wisconsin. 2 min. to next stop.

141.7 Turn left onto Wis. 23.

141.9 Turn left into gravel pit for STOP 8 805 ft. bar of Later Lake Oshkosh showing red clay stain and lenses of perfectly assorted gravel. Bar must have been built by northerly winds blowing off ice. Return to road corners to east. 15 min to next stop.

142.1 Turn left north on K and go north along foot of Niagara escarpment. Note that springs on top of underlying shale have caused much post-glacial sliding.

144.2 Turn right onto Wisconsin 31.

144.5 Turn left at Peebles following 31. From here north the highway follows on or close to the 805 ft. beach of Later Lake Oshkosh. Maximum level of 830 ft. is not shown well here.

148.4 Turn right onto County Highway Q and make STOP 8 at top of steep rise. 10 min. The road gutter northeast of the house shows what seems to be beach gravel of Early Lake Oshkosh overlain by red till. Elevation about 850 but this deposit may not have been made in a lake which was joined to that which discharged at Portage. 1 min to next.

148.6 Turn right onto town road.

148.8 STOP 9. View from Niagara escarpment over lowland floored by Galena dolomite. The Richmond shale is concealed by drift. Note the straight and regular outline of the escarpment. Martin ascribes this to glacial erosion. The fact that the fissured dolomite lay on soft slippery shale offered an optimum condition for glacial erosion. The Niagara escarpment was very important in directling the glacial lobes although the Green Bay Lobe on the west overrode it for some miles. The fact that so insignificant a feature affected lobation seems to show that continental glaciers were not ice rivers but oozed out along the margin where the slope sufficient to permit of gravitational flow was maintained during growth of the ice sheet at least by radiating winds which brought snow to the margin plus deposits from impinging cyclonic storms. This fundamental difference from valley glaciers may well give us pause with regard to wholesale glacial erosion. 13 min. to next stop.

149.1 Edge of red till; gray drift beyond.

150.4 Turn left onto County Highway U.

152.6 Recessional moraine of Middle Wisconsin trending NE-SW.

154.0 Turn right (south) on town road.

155.3 STOP 10 5 min. The drumlins of this district trend both to SW and to S. The writer explains them as first formed by Early Wisconsin Lake Michigan lobe moving southwest. A movement of the source of ice to the west during Middle Wisconsin time caused the Green Bay Lobe to occupy the same district moving south to east of south. This reshaped many of the drumlins by a process in part erosion but mainly deposition. Drumlin east of stop has new tail built on. Important light is thus thrown on origin of drumlins and glacial erosion shown to be slight.

155.8 Turn right on town road. (10 min to next stop)

156.4 Turn left on town road.

157.9 Turn left onto AA. Follow AA around curve to right.

159.7 STOP 11 On crest of overriddon drumlin. 10 min. Further discussion of overriddon drumlins. Lake Michigan part should have only Niagara pebbles

160.0 Turn left onto Wis. 23 and continue east. Cross several isolated patches of morainal drift. 35 min. to end of run.

171.1 Greenbush (detailed log ends) East of Greenbush we cross the famous Interlobate Moraine. Two different views of its origin have been held. The early geologists held it to be two opposed terminals formed by the respective lobes. Later students have thought of it as made in the reentrant angle between the lobes and not all at once. This later interpretation explains the gaps. Glacial drainage was confined between the lobes and thus the stony till was largely reworked into assorted deposits chiefly gravel. Buried ice masses later melted to make kettles. As the angle widened out the older deposits were terraced for the most part before the isolated ice masses had all melted. East of the summit several such terrace levels and an abandoned drainage channel are well shown.

177.1 Plymouth. Night at Curtiss Hotel.

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0.0 Leave Plymouth on Wis. 23 retracing route taken yesterday.

2.0 Turn right onto County Highway P and soon ascend Interlobate.

4.5 STOP 1 Gravel Pit of Moraine Sand and Gravel Co. Note foreset bedding. Mullet River here crosses through a gap. 10 min. from start. Stop 10 min. Continue on P under R. R. 5 min to next stop.

4.7 Pick up County Highway A and turn north on it.

5.3 Turn right with A.

5.5 Good view of moraine on left.

5.9 Turn left with A and make STOP 2 at top of grade. 5 min. View of Crystal Lake in kettle of pitted gravel terrace. 20 min to next stop.

7.0 Keep on A.

8.7 Elkhart Lake. Turn right at R. R. station heading east on A.

9.2 Pitted outwash well developed

10.2 Leave pitted outwash and enter till of Lake Michigan Lobe.

12.5 Thin edge of Late Wisconsin red till. No endmoraine.

13.8 STOP 3 Franklin gravel pit. Middle Wisconsin morainal gravel, overlain by gray till in turn buried by red till. 15 min. 40 min to next stop.

14.5 Turn right on A Red till ground moraine.

18.5 Turn right on A into village.

18.8 Turn left and cross Highway 32.

19.8 Turn right (east) on A.

21.5 Morainal topography to north possibly inherited from buried Middle Wisconsin terminal.

22.8 Turn left onto U. S. 141.

28.0 CAUTION: SLOW and close up for left turn at stop ahead.

28.7 Turn left into gravel pit south of Fisher Creek. STOP 4 15 min. Gravel underlying red till shows in part the assortment which is characteristic of beach deposits. May be Glenwood or pre-Glenwood beach of Early Lake Chicago formed during recession of Middle Wisconsin. Continue north on 141 into Manitowoc. 50 min. to next stop.

43.7 Turn left onto 21st. Street and go north across river.

45.0 Turn right (east) onto New York Ave.

45.7 Turn left (north) onto Wis. 42.

46.2 Turn right on 42 soon reaching shore of Lake Michigan. Much of the route to Two Rivers is along sandy beach with dunes.

51.0 Two Rivers continue on 42. Traffic lights.

52.1 Turn right on 42 on 22nd St. New bridge. Continue east on 22nd.

52.8 STOP 5 New Ball Park. 5 min. 17 ft. beach of Lake Algonquin. Cut in bank in spring of 1933 showed red till overlying older silt and lake sand/ Continue ahead on town road, 30 min to next stop. Route follows barrier beach of Lake Nipissing (24 ft.).

54.7 Turn left just south of creek soon crossing line of sand dunes.

56.1 Turn right onto Wis. 42 and continue north over red till ground moraine. Flat topography partly due to older lake deposits below.

64.5 Turn right at Two Creeks onto town road.

65.4 Keep straight ahead down lane to lake shore. Park cars and walk south along beach. Note intercision of creek. 1 hour stop. The best exposures of the Forest Bed are nearly a half mile south. Some digging may be needed. STOP 6. 20 min to lunch stop.

66.5 Proceed back to 42 and turn south to Two Rivers. lunch at Hotel Hamilton. Continue on 42, 13 min run back to Manitowoc.

82.9 STOP 7. Gravel pits. Upper layers disturbed by ice but no red till. Later lake deposits unconformable above. 30 min. 10 min to next stop. Continue south on 42 into Manitowoc.

83.5 Turn right onto New York Ave.

84.2 Turn left and cross bridge and lowland.

85.0 Turn right into trail to clay pit.

85.8 STOP 8. Pit of Medusa Portland Cement Co. Permission to visit at own risk secured by F. T. Thwaites from Cleveland office. 25 min. Red till overlying varved clays (disturbed by shove) which lie on gray till. Return to 21st. St. and go south. 30 min to next stop.

86.3 Turn right onto Washington Ave., Wisconsin 31. Follow 31

89.5 Red till moraine

92.4 Red till over gray till in road cut showing that topography is inherited.

97.4 Morainal topography, gray till shows in places.

100.6 Turn right (north) onto Wis. 148. Continue north up rock hill.

100.9 Turn left just north of house on left.

101.4 STOP 9. 20 min. Crossing striae on Niagara dolomite. Roshaped drumlins. The Late Wisconsin ice which reached this locality must have crossed the Door County peninsula and then spread out westward over the lowland east of the Interlobate Moraine. 15 min to next stop. Return to 31.

102.1 Rejoin 31 and go southwest.

107.3 Entering interlobate moraine partly overridden by red till.

108.3 STOP 10. 5 min. See interlobate moraine. There is a gap to north. Beyond that the interlobate is all buried by red till. It stops in Kewaunee County about 30 miles to north. 45 min to next stop.

109.4 Note conical moulin kame on left, the first seen.

110.5 Turn left (south) onto Wisconsin 32. Leave Late Wisconsin drift.

118.2 Turn right with 32

118.6 Turn left with 32 across bridge. Kiel.

119.1 Turn right onto Wis. 57.

121.4 Extremely pitted topography of Interlobate.

124.6 Elkhart Lake. Turn right onto County Highway A. Retrace out route to

131.5 Greenbush. Turn left on Wis. 23.

131.7 Turn right onto County Highway A.

132.5 STOP 11. Ice contact face of Interlobate without till, suggesting temporary stagnation of ice. Continue on A. 5 min to next stop. 5 min.

133.4 STOP 12. Large kettle in summit of interlobate which is here a terrace. 10 min. To southwest is a moulin kame which must be older, possibly formed some distance back from ice margin. 15 min. to next stop.

133.7 Well marked terracing.

134.1 Kame with flat top on right.

134.6 Descend to a lower terrace.

135.2 Well-marked outwash terrace. Turn right onto Wis. 67 (paved).

136.2 Branches of interlobate both right and left.

138.7 Turn left onto County Highway V. From here south pass through a group of moulin kames.

140.0 STOP 13 10 min to see kames. 40 min to next stop.

141.2 Turn left on V, McMullin Hill.

142.1 Cut in crevasse filling, turn left following V

143.7 Parnell, turn right onto A.

144.6 Turn right with A.

145.1 Turn left with A.

146.6 Turn right with A.

147.1 Left with A.
149.5 Right with A. Beechwood.
151.8 Right on S. County line.
154.1 Left with S.
156.0 Turn right
156.6 STOP 14. 10 min. Cut in moulin (?) kame showing forcset bedding. 20 min to end of day.
157.6 Turn left on S.
159.6 Moulin kame on left illustrated by Aldon.
159.8 Turn right onto Wis. 28 at Kewaskum.
160.2 Turn left into Wis. 55. Go south.
167.5 West Bond, Hotel Goib.

August 6, 1933
0.0 Go north on 55 to Barton retracing yesterday's route. 10 min to stop.
1.2 Barton, turn left into town road.
2.6 STOP 1 Pit of Northern Gravel Co. 25 min. Park cars off road and climb to top of strip dump. Forcset or slumped bedding. Return to cars and go on west through some very striking topography. 12 min. to next stop.
3.3 Turn left on town road.
4.1 Turn left onto County Highway B.
5.0 Turn right onto Wis. 33.
7.3 Turn left onto J. STOP 2, 10 min. to see glacial drainage channel, outwash terraces, and till interlobate to west. 5 min. to next stop.
10.1 STOP 3 5 min. Crevasse fillings to left including island. 15 min. to next stop.
14.9 Turn right onto Wis. 60. Interlobate here is nearly all gravel.
15.9 Turn left into town road. When fresh cuts showed gravel despite numerous boulders.
16.7 STOP 4. Sugar Loaf Hill, also known by other names. 15 min. Pit shows faulting in horizontally stratified sand and gravel. Apparently a moulin kame. Continue on town road. 15 min to next stop.
17.9 Turn right onto County Highway E. Descend ice contact face of interlobate. Gravel and till much mixed.
18.4 Turn left onto K. Ascend gradually to top of moraine. Crevasse filling to right suggest stagnant ice. Holy Hill soon seen to left.
23.5 STOP 5 5 min. to view Holy Hill from top of till interlobate. 20 min to next stop.
25.7 Sharp right turn up steep hill in bouldery gravel. Glacial drainage channel to left (Oconomowoc River) Here drainage from the Lake Michigan Lobe crossed the line of the Interlobate into Green Bay territory. There is no real Interlobate for several miles south of here.
25.9 Turn left on terrace.
26.2 Turn right
26.7 Turn left
27.0 Turn right and follow winding road through pitted outwash to
28.2 Turn left into Wis. 83. Follow 83 through North Lake, where there is a large gravel pit in end of terrace across pitted plain with till knoll.
31.3 STOP 6 5 min. Junction 83 and K. Much pitted outwash in golf links. Turn right onto K. 20 min to next stop.
33.2 Turn left onto County Highway C. Follow crevasse filling between Mouse and Okauchee Lakes. Pitted outwash with some till knolls?
39.2 Delafield, turn left onto Wis. 30. Hill to south formerly called Government Hill. Now the name Lapham Peak (after Lapham who lived near here) has been placed on this hill having been displaced by name Holy Hill where first applied.
40.4 STOP 7 Park cars at right and climb onto interurban track. Terraces along side of Lake Nagawicka show that ice block reached surface

10 min. 5 min. to next stop.

41.0 Turn right onto Wis. 83.

41.2 Park cars in gravel pit at left. STOP 8 15 min. Climb to top of pit to view glacial drainage outlets. At first water from Lake Michigan Lobe discharged to south. When ice block in Lake Nagawicka melted enough outlet changed to west for here the Green Bay ice melted first. This gave higher gradient and beheaded old channel. Lake Nagawicka ice block lasted until drainage had ceased. 5 min to next stop.

43.4 STOP 9 View of outwash terraces near Statesan. The number of such terraces is legion. As the ice reentrant broadened successively lower and lower outlets became available. 35 min to next stop.

44.0 Turn right onto U. S. 18 and go west past old R. R. gravel pit in very bouldery gravel.

44.7 Drainage outlet previously seen. At first this discharged to south but later to west along Scuppernong Creek.

45.4 Drainage outlet.

46.2 Terrace edge.

47.8 Same

48.2 Turn right onto Wis. 67. Go north on lowest outwash plain past several lakes in kettles.

51.2 Turn left onto Wis. 30.

53.0 Island of terminal moraine rising through outwash.

57.0 Last of outwash. Enter drumlin area.

60.7 STOP 10. Eskor between drumlins. 5 min. 10 min to next stop.

63.2 Turn left onto County Highway D and go south.

66.7 STOP 11 5 min to see drumlin topography. 10 min to next stop.

67.7 Turn left on U. S. 18. Continue east through fine drumlins and cross bridge over R. R. SLOW, sharp turn ahead.

70.0 Turn right and recross R. R. at grade. DANGER.

70.6 Pick up County Highway P and turn left.

70.9 STOP 12 2 min. Fine drumlins. 12 min to next stop.

72.5 Rome, Turn right into Wis. 90 and then left at west end of village.

77.1 STOP 13 on top of drumlin to see Interlobate Moraine face to southeast across Scuppernong Marsh. 5 min. 25 min to next stop.

81.8 Palmyra. Turn left onto Wis. 59. Continue northeast at foot of Interlobate.

86.1 Enter Interlobate.

87.5 Top of Interlobate. Highest or No. 1 terrace to east.

87.8 Turn off to right on gravel road, cross R. R. and pick up Wis. 99 on main street of Eagle. Continue east. Lunch stop here to be arranged.

88.9 Second terrace due to cutting away of glacial drainage outlet.

89.7 Turn right onto County Highway NN.

90.2 STOP 14. Discussion of terraces. 10 min. 15 min to next stop. The second gravel terrace was formed when new low drainage outlets, in part via Sugar Creek were opened to the south and drainage to the west was abandoned. It must be realized that stagnant ice masses were just as effective in this regard as living glaciers. All the terracing was accomplished rapidly before the ice blocks all melted.

90.9 Turn right.

93.4 Pick up Wis. 67 straight ahead.

98.7 STOP 15 5 min. 3 min to next stop. Recessional of Lake Michigan Lobe rises through outwash. Along this front the Lake Michigan (Delavan) ice retreated first and its territory was filled by outwash from the Green Bay ice. Continue ahead onto U. S. 12.

99.6 Turn right onto town road.

100.0 STOP 16. Walk into private road to left to top of hill. Fine view over pitted outwash plains with lakes from top of recessional moraine. 5 min. 15 min to next stop. Route over Heart Prairie which is an older terrace than that at Eagle.

102.1 Bird School. Turn right, North, onto County Highway H.

102.7 Turn left onto town road.

105.9 STOP 17. 5 min. Inside edge of Elkhorn Moraine where it joins the Interlobate. Old R. R. cut. 2 min to next stop. TURN RIGHT(north).

106.7 STOP 18. 30 min. Old R. R. cut through very stony till of Interlobate. Note that ground moraine on Green Bay side is much lower than Heart Prairie. 20 min to next stop.

107.2 Turn left onto County Highway P. Good view of cut just left.

110.0 Turn right onto town road.(west) Going west cross interlobate proper and enter on pitted plain between Johnstown and Milton Moraines.

114.0 STOP 19. 5 min. 5 min to next stop. Here see relation of Johnstown or endmoraine of Green Bay Lobe and Milton or first recessional.
Turn left (south) onto Wis. 89.
Going south cross Johnstown Moraine.

116.5 Go straight ahead leaving pavement.

116.8 STOP 20 at church. 5 min. 20 min to next stop. View of reentrant angle between Johnstown and Darien Moraines. In Alden's reports the latter is regarded as the end moraine of a separate lobe, the Delavan, but present day mapping shows that this lobe was only a minor excrescence on the side of the Lake Michigan Lobe.
Turn left and go through village of Richmond to rejoin 89. Follow 89 along border of Darien Moraine. Outwash to right somewhat eroded by glacial waters during ice recession from the Darien.

121.7 Turn left onto Wis. 20. Cross Darien Moraine and come into Turtle Creek drainage outlet. At crossing of creek note gravel pit to left on slip off slope of curve.

123.7 Turn right onto town road on outwash terrace. This outlet was used during the formation of the two highest gravel terraces at Eagle.

124.8 STOP 21. 10 min. 25 min to next stop. Gravel pit on left, now closed showed till of moraine resting on outwash. Good view of outlet.

126.7 Darien; right onto Wis. 14.

126.8 Left onto 89 at traffic light. From here 89 follows the edge of the moraine. To right outwash plain is found most of the distance. The low hills farther west are subdued drumlins of Illinoian age which trend southwest. They demonstrate a much greater extent of the Lake Michigan or Illinois lobe than occured later.

130.7 Turn left onto town road. Cross Darien moraine noting gray till.

134.0 Turn right onto Wis. 36 on ground moraine. Go south on 36.
CAUTION: steep grade down into Fontana with stop at bottom.

134.8 Turn right into gravel pit. STOP 22. 5 min to next stop. Ask permission at office. Ascend side of pit seeing section. Good view of Lake Geneva from top. History of lake involves a dual maximum of the Middle Wisconsin. First till is concealed. Recession to east of Elkhorn left ice mass in proglacial valley where lake now is. This was largely buried by outwash. Then readvance to Darien Moraine left till on top. Melting made much "false moraine" around the lake.
30 min. to stop here. Continue on 36.

137.2 After bad R. R. crossing (CAUTION), turn left on County Highway B.

138.7 Park cars east of overhead R. R. crossing and walk back for STOP 23.
This view shows the reason for the early misinterpretation of the souther extension of the Darien Moraine. Alden shows it curving back into Wisconsin to the east and joining the Valparaiso Moraine which Leverett had mapped as the border of the Middle (Late) Wisconsin. Recent study has traced the West Chicago moraine northwesterly into the Darien crossing the older Marengo Moraine at a marked angle. The Darien-West Chicago is clearly an endmoraine of a substage as it is bordered by non-pitted outwash. It shows a marked westward shift of the center from which the ice came. This westward movement of source is marked from Illinoian time on and explains the changes in lobation for the lobes were mainly marginal features and the direction from which the ice approached local topographic features affected their shape. The change

also affected the color and nature of the tills. The Early Wisconsin till of Marengo Moraine is probably red because derived in part from the red beds at the base of the Niagara not far distant. The Darien till is gray and stony because it came from a different direction and the ice overrode outwash. The cause of the Late Wisconsin red till was discussed before. The westward progression of glacial activity is marked from the Illinoian to the Des Moines lobe. Exceptions are (a) the Iowan, if regarded as earliest Wisconsin, and (b) a Patrician readvance near Winnepeg which is later than the Keewatin advance. In Wisconsin, however, it seems to furnish a key by which the several Wisconsin substages can be separated. Reference should be made to the overridden drumlins near Fond du Lac. The new mapping, however, tends to minimize the Delavan glacial lobe. 20 min. stop. Turn cars around and go west to

139.7 Walworth. Night at Wayside Ho[illegible] north side of park.

August 7, 1933

0.0 Leave Walworth on Wis. 89 south over non-pitted outwash. The White Rock Moraine at the border of the Wisconsin drift has not been discriminated in Wisconsin nor have the age relations of this marginal drift to the Marengo Moraine been studied. The fact that the outwash between the two is not pitted has little significance because the upper part of this deposit is certainly derived from the younger Darien-West Chicago Moraine of Middle Wisconsin age.

2.5 Big Foot Prairie-Wisconsin-Illinois state line.

Here the writer turns over the discussion to the Illinois geologists. He wishes in closing to make it clear that the statements herein given are to be regarded in the light of suggestions. They were based on ideas gained on field trips with students and have not been checked by detailed study.

F. T. Thwaites

July 26, 1933

International Geological Congress Excursion, 1933
Summary of route - subject to ~~correction~~ change on account of wall conditions - mimeographed guide to be prepared from trial run just before the excursion

NIGHT AT Prairie du Chien
U. S. 18 to Bridgeport ~~terrace~~, jct. with Wis. 60; Wis. 60 to Boscobel; Wis. 27 to Fennimore; U. S. 18 to Verona; C. H. M to Middleton Jct.; C. H. S to Pine Bluff; C. H. P. to Cross Plains; Wis. 11 to Middleton; U. S. 12 to Madison; drive through U. W. grounds.
Lunch at Dodgeville; Night at Madison
Estimated distance 130 miles

U. S. 12 to jct. Wis. 159; Wis. 159 to jct. Wis. 123; Wis. 123 and town road to top of West Bluff (weather permitting); Wis. 123 to jct. U. S. 12 at Baraboo; U. S. 12 to ~~Kilbourn~~ Wisconsin Dells; Wis. 13 to Coldwater Canyon; backtrack to ~~Kilbourn~~ W.D.; U. S. 16 to Portage; Wis. 33 to Waupun; U. S. 151 to Fond du Lac; Wis. 23 to Plymouth with short detour on old route to see drumlins.
Lunch at ~~Kilbourn~~ W.D.; Supper at Fond du Lac
Estimated distance 155 miles; this is the longest day but this cannot be avoided unless either some of the stops near Prairie du Chien or the visit to Madison ~~is~~ omitted. The long trip east from ~~Kilbourn~~ W.D. shows little of interest

Northern Wis. 57 to Elkhart Lake; east on C. H. A to jct. with U. S. 141; north on U. S. 141 to Manitowoc: Wis. 17 to Two Creeks; backtrack to Manitowoc; Wis. 31 to jct. Wis. 32; Wis. 32 to Elkhart Lake; C. H. A and C. H. S to Kewaskum; Wis. 55 to West Bend
Lunch at Two Rivers
Estimated distance 125 miles

West on Wis. 33 to jct. with C. H. J; south on J to Slinger; west on Wis. 60 to jct. with C. H. K; south on K to North Lake; south on Wis. 83 to jct. with U. S. 18; west on 18 to jct. with Wis. 67; north on 67 to jct. with Wis. 30; west on 30 to jct. with C. H. D; south on D. to U. S. 18; east on 18 to jct. with Wis. 90; south on 90 to jct. with Wis. 59; 59 to Eagle; south on Wis. 67 to jct. C. H. N; south on N to jct. with C. H. K; west on K to jct. with U. S. 12; west on 12 to jct. with C. H. P; south on P to C. H. A.; west on A to Richmond; south on Wis. 89 to town road northwest of Walworth; town road to Wis. 36; Wis. 36 to Walworth.
Lunch at Delafield
Estimated distance 125 miles
Choice of Walworth or Delavan for night.

omit (Blackhawk Bluff monadnock - Alden p. 214
glacial lakes Baraboo and Wisconsin Alden 222-230

Obsolete

State of Wisconsin

GEOLOGICAL AND NATURAL HISTORY SURVEY

MADISON, WISCONSIN

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INTERNATIONAL GEOLOGICAL CONGRESS EXCURSION, 1933

Summary of route - subject to change on account of road conditions. Mimeographed guide to be prepared from trial run just before the excursion

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Estimated distance 155 miles; this is the longest day, but this cannot be avoided unless either some of the stops near Prairie du Chien or the visit to Madison is omitted. The long trip east from Wisconsin Dells shows little of interest.

North on Wis. 57 to Elkhart Lake; east on C.H."A" to jct. with U. S. 141; north on U. S. 141 to Manitowoc; Wis. 17 to Two Creeks; backtrack to Manitowoc; Wis. 31 to jct. Wis. 32; Wis. 32 to Elkhart Lake; C.H."A" and C.H. "S" to Kewaskum; Wis. 55 to West Bend
Lunch at Two Rivers
Estimated distance 125 miles

West on Wis. 33 to jct. with C.H. "J"; south on "J" to Slinger; west on Wis. 60 to jct. with C.H. "K"; south on "K" to North Lake; south on Wis. 83 to jct. with U. S. 18; west on 18 to jct. with Wis. 67; north on 67 to jct. with Wis. 30; west on 30 to jct. with C.H."D"; south on "D" to U. S. 18; east on 18 to jct. with Wis. 90; south on 90 to jct. with Wis. 59; 59 to Eagle; south on Wis. 67 to jct. C.H."N"; south on "N" to jct. with C.H. "K"; west on "K" to jct. with U. S. 12; west on 12 to jct. with C.H."P"; south on "P" to C.H."A"; west on "A" to Richmond; south on Wis. 89 to town road northwest of Walworth; town road to Wis. 36; Wis. 36 to Walworth.
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State of Wisconsin

GEOLOGICAL AND NATURAL HISTORY SURVEY

MADISON, WISCONSIN

Going east from the Wisconsin Dells the terminal moraine of the Green Bay Lobe of the Middle Wisconsin substage is crossed. Alden p 200 As the ice fell back from this moraine Lake Wisconsin extended eastward with unchanged outlet and level until the dam was broken by an outlet around the east end of the Baraboo Range. When this happened the waters fell to a level determined by the highest moraine which crosses the course of the present river ~~somewhere~~ south of the Range. The level of Lake Wisconsin then fell to that fixed by the sandstone ridge at the Dells ~~over~~ east of which the waters escaped through a low place in the moraine to join the ~~eastern~~ new lake which is known as Early Glacial Lake Oshkosh.

Several halts of the retreating ice front are marked by deltaic moraines ~~which were~~ deposited in this lake; when the cuts on the highway were fresh, they showed foreset bedding dipping west. Alden p 261 The early high levels of Glacial Lake Oshkosh left no definite beaches near Portage (Pop. 6308 elev. 811) since the open water areas in that locality were small because of islands and masses of stagnant ice. Some of the latter seem to have persisted until after the outlet had been cut down from ~~somewhere near~~ approximately 875 feet to about 825 feet, for at Pardeeville an outwash train enters the lake bed at the last elevation. This plain does not head in a moraine but instead in a large marsh which must have then been filled with ice. After the retreating border of the Middle Wisconsin ice cleared the Niagara escarpment northeast of Lake Winnebago the level of Early Glacial Lake Oshkosh fell so that the Portage outlet was not used. When the readvance which is called the Late Wisconsin or Red Drift occured, this outlet was blocked and the waters again occupied the Portage col at elevation about 825. Later, during the recession of the Late Wisconsin ice, the col was eroded to its present level, about 795 A. T. Little can be seen of the outlet from the highway, but it should be noted that the Wisconsin River persisted in its course from the Dells to the lower or preglacial part of its ~~course~~ valley south of the Baraboo Range although it is now higher at Portage than the Fox River which

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Description of route, continued
by F. T. T. 1

Going east from the Wisconsin Dells the terminal moraine of the Green Bay Lobe of the Middle Wisconsin substage is crossed. alden p 220 As the ice fell back from this moraine Lake Wisconsin extended eastward until the dam was broken with unchanged outlet and level by an outlet around the east end of the Baraboo Range . When this happened the waters fell to a level determined by the highest moraine which crosses the course of the present river ~~somewhere~~ south of the Range. The level of Lake Wisconsin fell to that fixed by the sandstone ridge at the Dells ~~over~~ east of which the waters escaped through a low place in the moraine to join the ~~eastern~~ new lake which is known as Early Glacial Lake Oshkosh. Several halts of the retreating ice front are marked by deltaic moraines ~~which were~~ deposited in this lake; when the cuts on the highway were fresh they showed foreset bedding dipping west. alden p 261 The early high levels of Glacial Lake Oshkosh left no definite beaches near Portage since the open water area in that locality ~~was~~ were small because of kt islands and masses of stagnant ice. Some of the latter seem to have persisted until after the outlet had been cut down from ~~somewhere near~~ approximately 875 feet to about 825 feet, for at Pardeeville an outwash train enters the lake bed at the last elevation. This plain does not head in a moraine but instead in a large marsh which must have then been filled with ice. After the retreating border of the Middle Wisconsin ice cleared the Niagara escarpment northeast of Lake Winnebago the level of Early Glacial Lake Oshkosh fell so that the Portage outlet was not used. When the readvance which is called the Late Wisconsin or Red Drift occured this outlet was blocked and the waters again occupied the Portage col at elevation about 825. Later, during the recession of the Late Wisconsin ice, the col was eroded to its present level, about 795 A. T. Little can be seen of the outlet from the highway but it should be noted that the Wisconsin River persisted in its ~~course~~ valley from the Dells to the lower or preglacial part of its ~~course~~ south of the Baraboo Range although it is now higher at Portage than the Fox River which

State of Wisconsin

GEOLOGICAL AND NATURAL HISTORY SURVEY

MADISON, WISCONSIN

flows into Lake Michigan. a levee ~~was~~ prevents flood water from entering the Fox Pop 873 elev 810 vicinity. From Pardeeville to ~~near~~ Fox Lake the route lies over ground moraine. An esker is passed just west of Cambria. Pop. 671 elev 801 West of Fox Lake Pop 901 elev 885 the Green Lake moraine, a recessional of the Middle Wisconsin, is crossed. A few low drumlins are seen near this point. alden p 296

Northeast of Waupun Pop 5768, elev. 888 the Waupun moraine is crossed. It manifests itself as numerous 30 to 50 foot knolls of very stony till in which large blocks of the local Galena dolomite make up almost the entire mass. alden p 298 At Lamartine not morpe this ~~rock may be seen~~ the Galena outcrops in the creek bed. About two miles east of this point red lake clay is ~~noticed~~ occurs and soon the road ascends over a low ridge with a few slight kettles. This was mapped by Alden p 319 as the terminal moraine of the Red or Late Wisconsin substage. However, studies elsewhere seem to indicate that this substage at its maximum did not last long enough for the formation of a true endmoraine. It is probable that this ridge has a core of gray or Middle Wisconsin drift.

Pop 26,449, elev of Lake Winnebago p 747

Fond du Lac is situated in the bed of Later Glacial Lake Oshkosh, formerly known as Glacial Lake Jean Nicollet. alden pp 324-325 Beaches occur ~~at levels of~~ from ~~850~~ 825 down to 795 feet but are not conspicuous at all points particularly on the west shores. This is explained by the winds which blew off the cold glacier forcing pack ice against that side of the lake.

Two miles east of Fond du Lac a beach at elevation 810 demonstrates the presence of northerly winds as it is ~~in the form of~~ a spit built out from the east shore. Extended studies of beaches of Lake Oshkosh by Thwaites have shown similar results. At this place the lake gravels are interbedded with and highly stained by red clay. Such deposits as this have little economic importance on account of the clay stain which cannot economically be removed by washing to permit ~~of~~ use in concrete aggregate. Moreover, such beach deposits are almost universally very small and thin.

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MADISON, WISCONSIN

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The eastern shore of later Glacial Lake Oshkosh lies along the foot of the Niagara dolomite escarpment. ~~This is caused by the outcrop of the~~ where that resistant formation lies above the weak Richmond shale. As pointed out by Martin the Niagara escarpment in ~~eastern~~ Wisconsin contrasts sharply with that of eastern Iowa and northwestern Illinois in being decidedly more even and smooth. ~~rather than ragged.~~ ~~It~~ There are very few outliers of the Niagara ~~appear to be present for a long distance.~~ in Wisconsin. Martin (Bull 36, pp. 230-235 there faster) ascribes ~~this straightness and simplicity~~ to glacial erosion. ~~Here the ice of the Middle Wisconsin invasion passed for some considerable distance nearly or quite parallel to the escarpment.~~ As the shale below the jointed dolomite ledges must have furnished a very slippery foundation, many large masses of rock were removed and the escarpment straightened to its present form. In the west and for that matter farther south glaciation was less vigorous and the direction of movement less well adapted to erosion. Other escarpments without shale were not so highly altered by glaciation.

Ascending the escarpment we pass the border of the Late Wisconsin Red till. ~~This~~ As formation thins out gradually, ~~so that~~ at the top of the grade weathering has largely destroyed its identity. The morainic topography is clearly due to deposits of Middle Wisconsin age which were later veneered with Red till..

East of the escarpment the route passes through a remarkable group of drumlins. ~~These~~ which are somewhat shorter and rounder than is common in Wisconsin. The most peculiar phenomenon is the variety of directions of the long axes; these fall into two groups: (a) west to southwest, and (b) south to south-southwest. Alden (p. 250) regarded these drumlins as due to erosion of terminal moraines by a change in ice direction and cited crossing striae as evidence. Thwaites suggests an alternative explanation. During Early Wisconsin substage the source of ice was farther east than later. This led to the very large ~~size of the~~ Lake Michigan Lobe ~~as is well shown in~~ of Illinois. The extension of this lobe

State of Wisconsin

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MADISON, WISCONSIN

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in Wisconsin is unknown north of the place where Marengo Ridge is buried by the Darien (West Chicago) moraine near the south border of the state. It seems fair to suggest that the southwesterly trending drumlins east of Fond du Lac were formed by Early Wisconsin ice whose terminal lay west of the Niagara escarpment. If this is correct, the cores of these drumlins should contain no Galena dolomite pebbles or boulders. ~~During~~ During Middle Wisconsin time the ice entered the Green Bay-Lake Winnebago lowland more directly from the north and spread out over the Niagara escarpment to the east, reshaping the drumlins and depositing over them drift which carries Galena dolomite fragments. A few drumlins seem to have escaped much alteration; others have had new tails built which trend south; some have two distinct tails; still others conform exactly to the later direction of movement. A few drumlins have the stoss side more gentle than the lee suggesting that they were caused by erosion of the older hills but most are typical in outline. Weakness of glacial erosion and origin of drumlins by a combination of shoving plus accretion are conclusions from the facts known at the time of writing.

Leaving the drumlin area the highway passes over ground moraine liberally mixed with small discontinuous patches of recessional moraines formed by retreat of the east margin of the Middle Wisconsin Green Bay Lobe. At Greenbush, not much the famous Interlobate Moraine is entered. Here the hills consist almost entirely of gravel, for melt waters were closely confined between the two lobes and reworked whatever till was deposited. In this area it is not safe to conclude that till is present because the surface is overlain with boulders, for many large ice-rafted stones occur ~~are present~~ in the assorted materials. The topography of the Interlobate is rugged in the extreme; knobs, ridges, and mounds with a relief of over 150 feet are interspersed with enclosed kettles. In many places the slopes

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~~seem to have been determined by~~ are that of the angle of repose of wet ~~gravel~~ gravel. over 30 degrees. Much of the Interlobate or Kettle Range is wooded. ~~and From a distance stands out like a small mountain range.~~ It Although it ~~forms~~ the highest land between Lake Michigan and the Fox-Winnebago lowland it forms a water parting in but few places for there are many breaks through which streams pass. When the margins of the two lobes stood close together, assortment of the material was not good and coarse, ill-assorted bouldery gravels were formed in the reentrant. When included ice masses and the supporting ice walls melted, irregular ridges, knolls, and cones of gravel were left. ~~which~~ There are called kames. In a few places the conical hills may represent cones formed at the bottoms of moulins; other coarse gravels were doubtless deposited in open crevasses. When the angle widened, new lower outlets were opened for the meltwater and terraces of better sorted gravels were formed. Many ice blocks still survived buried in the sediments and later melted to form terraces of pitted outwash. The mapping by Alden did not in general attempt to separate till moraines, kames, and pitted terraces although he mapped the larger non-pitted or slightly pitted outwash deposits. Several distinct terrace and drainage channel levels with unconsumed remnants of older higher levels rising above them, can be seen along the highway approaching Plymouth. Pop 3882, elev. 845 Just west of the city a moraine, largely gravel, marks the western side of the Lake Michigan Lobe at the time of formation of the lowest terraces. Alden pp 304-309

Thwaites, F T. The origin and significance of pitted outwash. Jour. Geology, vol. 34, 308-319, 1926

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GEOLOGICAL AND NATURAL HISTORY SURVEY

MADISON, WISCONSIN

Pop 571, elev. 946

The highway from Plymouth to Elkhart Lake is through terraced and pitted outwash like that seen west of Plymouth. At Elkhart we turn east through more pitted outwash and by a recessional moraine of the Lake Michigan lobe. The first Red Drift is observed just east of a school house on the south side of the highway but there is no terminal moraine at the margin of this substage. About a mile west of Franklin, not morph. at the top of a steep sescent to the east, is a large gravel pit. Here the bright red till of the Late Wisconsin overlies kame gravels of an older Middle Wisconsin or "gray" recessional. Locally some gray till of the older glaciation occurs between the gravels and the red till. At other places the older sediments have been folded by the overriding Later Wisconsin ice.

East of Franklin the country is low and nearly level ground moraine of the Late Wisconsin. The topography is due to several factors: (a) clay tills, such as the "red" drift flow when wet and form level drift plains; (b) much of the red drift overlies gray outwash plains, and (c) much of the red till overlies older lake deposits.

East of Howards Grove, not morph. a low ridge of red drift contains some kettles and was mapped by Alden as terminal moraine; such features may be like the moraine farther west, inheriting their topography from buried Middle Wisconsin moraines.

Turning north we recross this belt of weak moraine at St. Wendel. not morph. At Fisher Creek gravel pits west of the highway expose a section of gravel under the red till. alden pp 312, 330 The gravels which by their bedding and excellent assortment of some of the thin layers show beach origin. Although the elevation of the top of the gravels is not known, it is fair to suppose that they are part of the Glenwood beach formed in Lake Chicago during the retreat of the Middle Wisconsin ice. although alden thought that they might have been deposited in a local lake at a higher level.

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State of Wisconsin

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GEOLOGICAL AND NATURAL HISTORY SURVEY

MADISON, WISCONSIN

pop 22963 elev of Lake Michigan 581

From Fisher Creek to Manitowoc little of interest is seen. The exact extent to which the land was submerged by the Calumet stage of Glacial Lake Chicago, 40 feet above the present, is not known on account of lack of topographic maps. Alden p 332

Just north of Manitowoc several gravel pits can be seen on both sides of the highway. The gravels are deltaic deposits probably made at the margin of the ice in the Glenwood stage of Lake Chicago. Lake silts and clays, much disturbed by ice shove, overlie a large part of the deposits, but no till has been discovered. In places weathering of these clays has carried calcium carbonate into the gravels cementing them into conglomerate. In places beach sands and gravels, probably of Calumet age, overlie the folded beds unconformably. It is suggested that the waters of Later Glacial Lake Chicago reworked and obliterated the thin red till left on the top of the deltas. The silts and clays may have been deposited in front of the advancing late Wisconsin ice.

From Manitowoc to Two Rivers pop. 10082, the highway runs on the beach of Lake Michigan. Sand dunes may be seen on both sides of the road. Goldthwait pp 57-59

At Two Rivers the Nipissing ~~Tahextanx~~ and Algonquin (Toleston) beaches are well shown both as cliffs and barriers. North from the city, much of which is on sandy Nipissing lake bottom, the highway passes along a ridge of ~~clayey~~ red till which locally resembles a weak terminal moraine. ~~Its significance is unknown.~~ No trace of the Calumet beach is known north of Two Rivers ~~so that~~ this ridge may mark the ice border at the maximum extent of that stage of Lake Chicago. Goldthwait pp 59 - 61, 109 - 119

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GEOLOGICAL AND NATURAL HISTORY SURVEY

MADISON, WISCONSIN

Mp 61-62

The Two Creeks Forest Bed was discovered by Goldthwait, later explored to some extent by Thwaites, and last worked on in detail by Wilson (unpublished)

The following section is exposed:

Algonquin — Clay, red, and yellowish gray, varved, dolomitic, ~~probably deposit of Lake Algonquin~~, found ~~only~~ up to about 25 feet above Lake Michigan	5
Late Wisconsin — Till, red, clayey, dolomitic, ~~evidently Late Wisconsin~~ some wood	8-15
~~Lake~~ Silt, and clay, red, dolomitic, some shells	½
Interglacial ~~glacial~~ Forest Bed-peat, stumps, logs, branches, etc , local distribution	½
Glenwood — Clay, sand, and silt; clay, red, silt, gray to yellowish gray, dolomitic, top part contains organic remains	7-12
Middle Wisconsin — Till, clayey, gray, dolomitic, ~~apparently Middle Wisconsin~~.	3

Wilson found that spruce is the only determinable wood ~~present~~ although pollen of jackpine ~~xxxxxx~~was discovered. He found 19 species of mosses and 7 of mollusks. Fungi, mites, beetle excavations on logs, and pollens of several upland plants were also ~~found~~ collected. The flora and fauna indicate a colder climate than today, one like that of northern Minnesota at present.

A similar section is also exposed in the pit of the Manitowoc Portland Cement Company at Manitowoc except that no Forest Bed is present. ~~Here~~ The elevation of the clays ~~suggests~~ ~~that elevation~~ that they were deposited in the Glenwood stage of Lake Chicago.

At both places the amount of disturbance due to the Late Wisconsin ice varies widely. Locally the underlying beds seem to have been buried by lake sediments and little disturbed by glacial shove. A few feet away ~~the entire series~~ all the sediments below the red till ~~is~~ are highly folded and contorted ~~beyond recognition~~. Great ~~masses~~ boulders of silt, clay and gravel are found in the red till. Locally masses of vegetal remains have been mingled not only with the stratified beds but even with the basal ~~xx~~ gray till, The surface on which the forest grew undulates considerably and followed both to north and to south of the exposures disappears below lake level.

The evidence of the Forest Bed fixes the low water stage of Lake Chicago between the Glenwood and Calumet stages (Alden, Mp 332-335)

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Till, red, clayey, evidently Late Wisconsin (some wood)	8-15
Silt, and clay, red, dolomitic some shells	½
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Alden 332-335

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GEOLOGICAL AND NATURAL HISTORY SURVEY

MADISON, WISCONSIN

West of Manitowoc a marked terminal moraine is crossed which is probably of Middle Wisconsin age veneered with red till. Cuts in another moraine farther west show ~~that this is a fact~~ a basement of gray till

The quarry at Valders ~~is interesting because it~~ (pop 504, elev 812) shows the relations of the Middle and Late Wisconsin ice sheets. The ~~rock~~ reef is a reef of Niagara ~~age which forms a low hill~~ dolomite. The till above the rock varies from 5 to over 10 feet in thickness. At both north and south ends of the opening gray till is found beneath the red; in the center only red till occurs. Where gray till is present the only striae trend approximately south but where the red till rests directly upon the rock, striae bearing about west also occur ~~or~~ and locally obliterate the older markings. These demonstrate that the ice of the Late Wisconsin substage moved west, for they are best developed on the east-facing sides of the older grooves. About two miles northwest of this point Alden (pp 317-318) discovered striae beneath gray till which he thought indicated a southeasterly movement; in the light of the information now available at Valders, it is more plausible to suppose that the movement was northwest and that the ice of the Late Wisconsin Lake Michigan lobe extended much farther west, ~~to the moraine which is well shown along the highway several miles west of Valders.~~ The thin edge of the red till of the Late Wisconsin is very difficult to trace and therefore its lobation is hard to determine. The ice which reached Valders must have crossed the upper end of the Door County peninusula between Green Bay and Lake Michigan and then spread out in the low ground west of Lake Michigan where the Green Bay lobe could not cross the high interlobate moraine of Middle Wisconsin age.

~~The~~ A prominent moraine ~~mentioned above~~ which is crossed west of Valders is mapped by Alden as a recessional of the Green Bay lobe. However, it contains very little, if any, Galena dolomite and it has been suggested by Thwaites that it is the Interlobate of the Middle Wisconsin. Reconnaissance to the north tends to confirm this suggestion. ~~Where this moraine is first seen it~~

~~may have been~~

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MADISON, WISCONSIN

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The quarry at Valders ~~is interesting because it~~ shows the relations of the Middle and Late Wisconsin ice sheets. The ~~rock~~ till is a reef of Niagara ~~age~~ dolomite ~~which forms a low hill~~. The till above the rock varies from 5 to over 10 feet in thickness. At both north and south ends of the opening gray till is found beneath the red, in the center only red till occurs. Where gray till is present the only striae trend approximately south but where the red till rests directly upon the rock striae bearing about west also occur ~~or~~ and locally obliterate the older markings. These demonstrate that the ice of the Late Wisconsin substage moved west for they are best developed on the east-facing sides of the older grooves. About two miles northwest of this point Alden (pp 317-318) discovered striae beneath gray till which he thought indicated a southeasterly movement; in the light of the information now available at Valders it is more plausible to suppose that the movement was northwest and that the ice of the Late Wisconsin Lake Michigan lobe extended much farther west ~~to the moraine which is well shown along the highway several miles west of Valders~~. The thin edge of the red till of the Late Wisconsin is very difficult to trace and therefore its lobation is hard to determine. The ice which reached Valders must have crossed the upper end of the Door County peninsula between Green Bay and Lake Michigan and then spread out in the low ground west of Lake Michigan where the Green Bay lobe could not cross the high interlobate moraine of Middle Wisconsin age.

A prominent ~~The~~ moraine ~~mentioned above~~ which is crossed west of Valders is mapped by Alden as a recessional of the Green Bay lobe. However, it contains very little, if any, Galena dolomite and it has been suggested by Thwaites that it is the Interlobate of the Middle Wisconsin. Reconnaissance to the north tends to confirm this suggestion. Where this moraine is first seen it ~~may have been~~

State of Wisconsin

GEOLOGICAL AND NATURAL HISTORY SURVEY

MADISON, WISCONSIN

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State of Wisconsin

GEOLOGICAL AND NATURAL HISTORY SURVEY

MADISON, WISCONSIN

This moraine where first seen has

it is not certain but that ~~it may have~~ been overridden by the Late Wisconsin for ~~some~~ red clay and till is found in some of the kettle holes. Surveys by Thwaites have shown that similar overridden moraines near the border of the Red till were little altered and in many places it is difficult to prove the presence of a later drift. This pehenomenon of disappearance of a thin till through weathering and erosion doubtless explains the peculiar border of the Iowan drift in Iowa, long a source of ~~wonder and~~ perplexity if not a reason for doubting the existence of such a drift.

Elkhart Lake

The route south to Kiml passes through the same moraine. From Elkhart Lake we pass over pitted outwash terraces to Glenbulah. Crystal Lake with its steep gravelly shores, islands, and large number of ~~summer homes~~ cottages is a typical kettle lake ~~as now~~ developed as a summer resort.

The large commercial pit at Glenbulah (Elkhart Moraine Sand and Gravel Company) appears to be a delta kame formed in the reentrant between the Green Bay and Lake Michigan lobes. From Glenbulah to Greenbush we follow the foot of the west side of the Interlobate

south to Dousman

From Greenbush ~~to Hartford~~ the route lies almost wholly in the Interlobate moraine and its associated outwash terraces. Alden pp 269-270, 283, 289-293 Two very high peaks, one of which is a kame which was probably deposited in a moulin some distance from the open part of the ice reentrant, may bee seen. These are Sugar Loaf or Pulforts Peak, southeast of Hartford, elev 1320 and Holy Hill, which is surmounted by a Catholic church, elev 1361 South of From North Lake, where there is a large commercial gravel pit in a terrace, the Interlobate is not present for several miles until it is resumed in Lapham Hill formerly known as Government Hill, elev. 1233 Lapham was one of the early State Geologists of Wisconsin and ~~his name had been assumed~~ what is now Holy Hill was formerly named Lapham Peak. When this name was superseded ~~displaced~~ it was moved to replace the meaningless name of the lower hill ~~farther~~ to the south.

State of Wisconsin

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The ~~absence of any~~ break in the Interlobate ~~ridge~~ is due in large part to the fact that streams fed by the melting Lake Michigan lobe here crossed ~~the~~ into the area just vacated by Green Bay ice. Farther south, east of Delafield, there are several abandoned stream channels ~~which were worked out by~~ (Alden, pp 291) That followed by ~~Highway~~ Wis. 30 seems to have been the latest ~~and to have~~ It carried water from a block of ice in the basin of Pewaukee Lake west across a stagnant block in Lake Nagawica to the Bark River, a tributary of the Rock. At an earlier stage this stream must have gone south through the valley which lies just below the State Tuberculosis Sanitarium. At first this valley probably ~~led~~ south (exchanged waters near Eagle) but later recession of the Green Bay ice opened an outlet to the west now followed by Highway 18. Melting of the Lake Nagiwicka block then diverted the headwaters of the stream to the west and the shorter course soon entrenched itself leaving the head of the Sanitarium valley hanging. ~~as is well shown on the Oconomowoc quadrangle.~~

From the Interlobate of the Delafield (pp not morp) region the route takes us west into a typical drumlin landscape. The drumlins of this region trend slightly east of south, for they were deposited by the southeasterly quadrant of the Green Bay lobe. (Alden pp 253-256, & Bull 273) Eskers may be seen between the drumlins. (alden pp 284-288) Instances of crossing of drumlins by eskers are rare in Wisconsin; for the most part the gravel ridges ~~keep~~ are confined to the low swampy tracts between the drumlins. ~~as the drumlin area does not extend~~ ~~Drumlins are left south of Rome for they do not approach~~ within several miles of either the terminal or interlobate moraines. Much of the low ground along Scuppernong Creek was the site of a temporary glacial lake until ~~the erosion of its outlet across~~ an outlet was eroded through the moraines to the southwest. ~~obliterated it.~~ no more drumlins are seen beyond a point a few miles south of Rome not inc

pop 642 elev 840 pop 392 elev 945

From Plamyra to Eagle the Interlobate is recrossed. From Eagle south is a remarkable series of outwash terraces, all of them pitted which ~~explained~~ was worked out by Alden as due to changes in drainage outlets due to ice recession. (Prof Paper 34, pp 44-49, 57-62, Prof Paper 106, pp 267-269, 275-277) The highest terraces were formed when the meltwater from the

State of Wisconsin

GEOLOGICAL AND NATURAL HISTORY SURVEY

MADISON, WISCONSIN

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Green Bay and Lake Michigan fronts escaped to the southwest to Rock River via the Turtle Creek outlet. Later Terracing was due to (a) erosion of this outlet, and (b) Theft successive uncovering of two lower outlets to the east via the Fox River of Illinois

~~Much of the mapping of the moraines in this region is in need of revision~~ Present day since modern exposures ~~have shown~~ show that ~~they~~ many moraines shown by Alden in this region are pitted and dissected terraces of sand and gravel.

Alden 258-259

The route leads across the Elkhorn Moraine, a recessional of the westward bulge of the Lake Michgan lobe ~~xxxxxxx~~ known as the Delavan lobe. Where the Interlobate is recrossed on Highway 12, its ~~southern~~ southeastern side is buried ~~xx~~ by outwash, and showing ~~that~~ here the Green Bay ice lasted longer than did the Lake Michigan glacier. In the abandoned railway cut the excessively stony character of the till is well shown. Much of the material was of local derivation. (Alden Prof. Paper 34, Mp. 53-56, 36)

At Richmond not morp the angle between the Green Bay and Lake Michigan lobes is seen ~~as shown in~~ where the Johnstown and Darien moraines ~~which northeast of here~~ coalesce into the Interlobate. Adjacent to this place the outwash, which is not pitted is highly dissected by waters which escaped after the ice fronts had receeded a few miles from their maximum. - Alden Mp. 235-~~238~~ 241 Prof Paper 34, 38-39

From Richmond south the route closely follows the outer edge of the Darien moraine and crosses the Turtle Creek drainage outlet. ~~This shows~~ which contains a marked terrace. A pit just north of Highway 20 was the source of coarse aggregate for the concrete paving.

At Darien ~~the~~ not morp the outside of the moraine is reached. To the southwest low rolling ground moraine and low gullied drumlins of the Illinoian drift can be seen contrasting sharply with the fresh uneroded knolls of the moraine.

Alden 34, 33-34, 106 & 232-234

Alden Mp 138-140

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Alden Pp 138-140

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GEOLOGICAL AND NATURAL HISTORY SURVEY

MADISON, WISCONSIN

pop 385 elev. of Lake Geneva 864

At Fontana an abandoned commercial gravel pit exposes very coarse bouldry horizontally stratified gravel beneath till which is a part of the Darien moraine. Some of the gravel has been cemented into conglomerate. The till extends only a short distance down the side of the gigantic kettle in which Lake Geneva lies. This depression is ~~on the site of~~ in a preglacial valley. Springs and wells show that Till lies beneath the gravels ~~as shown by wells~~. The history ~~recorded~~ is (a) advance of Middle Wisconsin ice depositing till, (b) recession to east of Elkhorn leaving gravels with buried ice blocks, (c) readvance to Darien moraine before all of the larger blocks were melted. (d) melting of ice blocks after last recession of ice ~~and~~ leaving the basin of Lake Geneva. Aldens mapping ~~infers~~ shows that the ridge south of the Lake is the main continuation of the Darien moraine but later studies in Illinois make this doubtful. The basin escaped filling because it was parallel to the direction of ice flow. alden 34, 30-31; 50; 106,

pop 920, elev. 1004

Southeast of Walworth the ~~northern end of~~ the red till Marengo Ridge moraine enters Wisconsin and is lost beneath the Darien moraine. Their relations will be explained during the trip in Illinois

alden 34, 22-24; 106, 182-183, 231-232

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State of Wisconsin

GEOLOGICAL AND NATURAL HISTORY SURVEY

MADISON, WISCONSIN

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DEPARTMENT OF THE INTERIOR In camp

GEOLOGICAL SURVEY Arlee, Mont

Aug 17, 1931

Dr. E. T. Bean &
Dr. F. T. Thwaites
University of Wis.
Madison, Wis.

Dear Friends, - In looking over some of the material to the Internat'l Guide Book which I have here in the field with me I am reminded that I did not send you a copy of the Wis. Ms. after I made numerous changes in it. I am therefore enclosing herewith the one carbon copy which I have of the revised Ms. Will you kindly look this over very soon if you can do so and if you wish changes made in it please send the changes to my secretary Miss Pearl F. Zeigel, U.S.G.S. Wash. D.C. She has all the material and will assemble it very soon to turn over to the Secy. Dr Ferguson for editing.

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UNITED STATES

DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

, 19

The Mss. seems somewhat long and the editors may want to cut it down somewhat. I was very much rushed trying to get together as much of the material as I could before leaving Washington for my summer's field work in Mont. This should have been sent on to you before this.

Inasmuch as I did not have all the Mss. together when revising them they are not just of the same style but that is not a serious matter. I think, I thought, in view of some of the changes perhaps my name should be inserted as co-author.

Hoping you are both having a pleasant and profitable summer, I am

Very truly yours

W. C. Alden

Geologist

Annotated guide of southern Wisconsin

by

E.F. Bean, F.T. Thwaites, and Wm. C. Alden

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Lake Geneva.....

XVI International Geological Congress

Guidebook No._____

Excursion No._____

The Pleistocene Glacial Deposits of the Upper Mississippi Basin.

Chicago

to adjacent parts of

Illinois, Iowa, and Wisconsin

and return.

June, 1933.

Annotated Guide

Southern Wisconsin

E.F. Beam

By F.T. Thwaites and Wm. C. Alden

Fourth day:

Prairie du Chien to Madison, Wis., (est. 130 miles, 209 km.).

Prairie du Chien (Pop. , ele. 640 ft. A.T., 195 m.[1]). The flat bottom of the trenchlike gorge of Mississippi River[2] between

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1/ Elevations approximate.

2/ See topographic maps of Waukon and Elkader (Ia.-Wis.) quadrangles.

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northeastern Iowa and southwestern Wisconsin is here 500 to 600 feet below the adjacent upland ridge tops, and wells show the presence of 150 feet or more of filling in the rock gorge below the present level of the river (high water, 626 ft., 190.9 m.) (p.2a). The general southerly dip of the rock formations is steeper than the gradient of the stream, so that the gorge which is 2 to 4 miles, (3 - 6 km.) or more in width farther north, where cut in the Cambrian sandstone, narrows southward as the more resistant overlying (Ordovician) "Lower Magnesian" dolomite approaches the river level and for some distance south of the

confluence of the Wisconsin River the towering walls of the gorge are but 1½ to 1⅝ miles apart. In consequence of the dip of the rocks being really southwesterly there is a similar downstream narrowing of the gorge of Wisconsin River. Prairie du Chien stands on a low sandy terrace, which slopes northward from the mouth of Wisconsin River as though part of a great alluvial fan built by that stream cut into the Mississippi flood plain (Martin 34, p. 145) at the Wisconsin stage of glaciation.

Bridgeport terrace, (ele. 700-800 ft., 214-244 m.). Five miles (8 km.) southeast of Prairie du Chien the route goes up onto a terrace 100 to 200 feet above the river at Bridgeport (Pl.III). It was cut into the dolomite by Wisconsin River at an earlier stage (Pre-Wisconsin stage, perhaps early Pleistocene or late Tertiary). Later the river cut its narrow inner gorge and the rock terrace was then dissected and finally mantled with 30 to 50 feet of bouldery drift and loess. MacClintock has (32, p.677) suggested that the deposition of the drift may have been due to a lobe of glacier ice from Iowa having crossed

the Mississippi gorge and invaded the mouth of the Wisconsin Valley at the Kansan stage of glaciation. Thwaites (42, p. 631) believes the erratics may have carried on floating ice from the east and that the till-like appearance of the material is due to slope wash, slump, and weathering.

Wauzeka terrace. - Several miles above Bridgeport, near Wauzeka and the mouth of Kickapoo River, is a terrace cut in Cambrian sandstone and mantled with glacial outwash (700-765 feet, 214-233 m.), 100 to 115 feet, 31-35 m. above the Wisconsin bottomland. The pebbles in the sand and gravel are largely of local rock, but with them are numerous erratics, granite, quartzite, porphyry, basalt, etc., similar to those in the glacial drift to the east. MacClintock (32) regarded this as outwash from the Kansan (?) drift on the Bridgeport terrace. Westward-dipping bedding was, however, noted in one high-level, gravel pit. This and other pits on the lower flat furnish surfacing material for local roads. The drainage basin of Kickapoo River to the

north is entirely within the Driftless Area. In the Kickapoo Valley are the largest apple orchards in Wisconsin. At Boydtown there are erratic boulders (713 A.T., 217 m.) 60 feet above the flood plain. MacClintock thinks old glacial gravel on a sandstone terrace probably came from the east and may be of Nebraskan age.

Boscobel (pop. 1,762, ele. 673 ft., 205 m.). Wells on the low terrace at Boscobel show 130 feet of sand and some gravel and the granite was encountered below the Cambrian sandstone at depths of 965 and 1,000 feet (294-305 m.). Leaving the river at Boscobel, the route runs south to the loess-mantled, driftless upland going up through Cambrian sandstone, "Lower Magnesian" dolomite, Black River (Platteville) and Galena dolomite.

Fennimore[1/] (pop. 1,341, ele. 1,196 ft., 365 m.) is in

1/ See topographic maps of Lancaster, Mineral Point, Richland Center, Blue Mounds, and Blanchardville (Wis.) quadrangles.

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the heart of a rich dairy region, with upland soil partly residual

from weathering dolomite and in part loess. The top of Military Ridge, on which the route and the Chicago & Northwestern Railway run eastward, is part of an old south-sloping, erosion surface to which the name Dodgeville plain has been applied. (See Trowbridge 44, p.64). Martin (34) and others regard the ridge as a north-facing cuesta (p.2) with maturely dissected slopes. (Photo 5).

p.2a.

Montfort (pop., 554, ele., 1,119 ft., 341 m.).

Cobb (pop. 276, ele. 1,175 ft., 358 m).

Dodgeville (pop. 1,937, ele. 1,253 ft., 382 m.). At Dodgeville there are two active zinc mines and several that are worked out. This is part of the southwestern Wisconsin lead and zinc district. Mining began in 1824. The first ore mined was Galena which was close to the surface or actually outcropped upon the hillsides. Many of these old shallow workings will be noted. Later mining developed the zinc sulphide, sphalerite. The ore occurs in the lower part of the Galena dolomite and the upper part of the Black River (Platteville) dolomite.

Blue Mounds (pop. 182, ele. 1,301 ft., 397 m.). West Blue Mounds has a height of 1,716 feet A.T. (523 m.) and about 400 feet (122 m.) above the surrounding upland. Blue Mounds are composed of Maquoketa shale capped by an isolated outlier of the dolomite Niagara limestone escarpment which is 69 miles to the east in Wisconsin and from 45 to 55 miles to the south and west in Illinois and Iowa.

East border of the Driftless Area.[1/] - Near the railway crossing 1.8 miles (2.9 km.), west of Verona, there is a little of the Illinoian glacial drift which farther south ~~is~~ near the Illinois-Wisconsin State line is spread over an area 50 to 60 miles (81-97 km.) wide outside the limit of the later drift (Pl. I). The southwest front of the Green Bay lobe of the Middle Wisconsin substage occupied a small valley about a mile east of the railway crossing and left its outer moraine crowded against the west slope, being separated therefrom by only a sharp ravine, 35 to 40 feet in depth. One side of

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1/ See topographic maps of New Glarus Cross Plains and Madison quadrangles.

this ravine is of nearly bare Lower Magnesian dolomite; the other is formed by the abrupt front of the moraine. In the next 1½ miles northward the moraine front rises abruptly 60 to 80 feet from a flat terrace to a well-marked ridge crest, back of which a belt one-half to 2 miles in width, marked by gentle sags and swells and several ponds, extends to a very indefinite inner margin. (Alden 3, p. 212.)

Verona (pop. 1,062, ele. 981 ft., 299 m.) - In the 25 miles (40 km.) north-northwest to Wisconsin River the relations of the outer margin of this glacial drift to the topography of the deeply dissected Driftless Area afford interesting studies.

Middleton (pop. 983, ele. 931 ft., 284 m.). - The outermost moraine of the Green Bay Lobe crosses Black Earth Creek obliquely, thus losing its relief in the general filling. Coarse outwash gravel from this moraine built up the valley train between Cross Plains and Black Earth. Gravel from the pits near Cross Plains is hauled as much as ten miles for road surfacing. ~~The saving (over rail hauled~~

Local plants here and east of Cross Plains are equipped to crush, screen and wash the gravel to meet rigid specifications. The saving to the public amounts to $2,000 to $5,000 per mile of paving. When the ice front retreated past the narrow gaps 4 to 5 miles east of Cross Plains, and thence by stages eastward to the recessional moraine at the west end of Lake Mendota, the basin of Pheasant Branch was flooded, forming glacial Lake Middleton (Thwaites), and in this basin notable outwash deposits and morainal deposits were laid down. (Alden 3, pp. 265-266.) One well on the flat penetrated sand 100 feet, peat 1 foot, and clay 125 feet before reaching the rock bottom of the valley. Some of this filling was probably deposited at an earlier stage.

En route from Middleton to Madison glimpses of Lake Mendota may be had. This is the largest of the four lakes near the city. These lakes occupy portions of preglacial valley of the Yahara River possibly somewhat broadened and deepened by glacial erosion in Cambrian sandstone.

Madison, (pop. 57,899. Elevaof Lake Mendota 849 ft., 259 m.). At Madison is the State Capitol, the State University, the Forest Products laboratory, and several manufacturing plants. The annual enrollmentat the university is about 10,000. Hotels Loraine, Belmont, and Park.

Fifth day, Madison to Fond du Lac[1/] via Kilbourn (est. 155 miles, 250 km.).

1/ See topographic maps of Baraboo, Denzer, Dells, Briggsville, and Portage, Wis., quadrangles.

Along most of the route from Madison northwest to the Wisconsin River Valley there are alternating belts of recessional moraine and ground moraine mantling the eroded surface of the Upper Cambrian or St. Croixan sandstone and the overlying "Lower Magnesian" dolomite.

Springfield Corners (ele. 966 ft., 295 m.). Bordering the river for two miles southeast of Sauk City is pitted and dissected outwash deposited at the western front of the Green Bay lobe. $22,000

was saved by using this local gravel (80 per cent limestone) in paving 10,5 miles (17 km.) of highway; on gravel from another pit, $23,000 was saved on 7.5 miles.

Sauk City (pop. 1,137, ele. 780 ft., 238 m.). Cross Wisconsin River (ele. 740 ft., 226 m.)

Prairie du Sac (pop. 949, ele. 800 ft., 244 m.). Adam on the river furnishes power to many places in southeastern Wisconsin. To the north the river cuts through a broad composite morainal deposit which overlies older valley filling, and which is bordered for miles on the west by a broad, high outwash terrace (Sauk Prairie). The towns stand on a lower terrace due to erosion of the outwash. For 8 miles the route traverses these terraces a short distance west of the morainal front; farther west are driftless hills of Cambrian sandstone.

Baraboo Range. - From the upper terrace the route runs up over a driftless part of the Baraboo Range composed of folded and truncated

Pre-Cambrian (Huronian) quartzite, which projects 300 to 800 feet (92 to 244 m.) above the eroded surface of surrounding Paleozoics and the drift. The South Range, 1 to 5 miles wide and 25 miles long, is joined at the ends by a less prominent north range forming a synclinal basin through which the Baraboo River flows.

Devils Lake, (ele. 963 ft., 294 m.). In preglacial time the Wisconsin River flowed through the North Range at the Lower Narrows on a valley bottom 200 feet below the present Baraboo River, then west and south through the Devils Lake gorge. The rock bottom of this gorge is thought to lie nearly 400 feet above the lake. At the Wisconsin stage of glaciation the west front of the Green Bay lobe overrode the South Range to a point 4 miles east of this gorge. On the lower ground to the north and south it advanced farther west and blocked the gorge at both ends with morainal dams, thus inclosing the lake basin. The lake has no inlet or outlet other than by percolation. A talus of great quartzite blocks flanks the steep walls of the gorge. The route crosses the terminal moraine northwest and north of the lake.

The Green Bay Glacier blocked the Baraboo valley at Baraboo, thus forming Glacial Lake Baraboo. At the same time Glacial Lake Wisconsin was formed in the lowland north of the Baraboo Ranges. Alden believes the waters of these two lakes were confluent and that they rose to a height of at least 960 A.T. (293 m.). The waters discharged to the northwest into the East Fork of Black River.

Baraboo (pop. 5,545, ele. 864 A.T., 264 m.). The city is located on the terminal moraine where the Baraboo River has cut through it. North from Baraboo the highway is on the outwash plain west of the terminal moraine. Much of this plain, which slopes gently westward, lies between elevations 960 and 980 A.T. (293 and 299 m.). It appears that much of the fill was deltaic. The upper part of the terrace, however, was built above the lake level. $55,000 was saved on paving 11.8 miles (19 km.) of this highway by using material from a gravel pit on this outwash terrace. 45 per cent of this gravel is from the quartzite ranges and but 22 per cent is from the limestone formations farther east. A well at this pit penetrated 304 feet of sand,

13a Insert on p. 13

The Dells of the Wisconsin River. - The recession of the west front of the Green Bay Glacier to a moraine near Portage cleared the Wisconsin valley and permitted glacial Lakes Wisconsin and Baraboo to be drained about the east end of the Baraboo Bluffs. The re-established drainage lines in new courses across the drift located Wisconsin River across a broad buried ridge of Cambrian sandstone in the vicinity of Kilbourn, which is west of the broad preglacial valley; and the erosion of the new channel, a narrow gorge cut in the cross-bedded sandstone, gave rise to The Dells, the most famous and beautiful feature of the Wisconsin Valley (Photo 6).

Baraboo River, instead of discharging to a stream flowing southward through the Lower Narrows and the Devils Lake Gorge, as in preglacial time, now flows eastward through the Lower Narrow and joins the Wisconsin near Portage.

Kilbourn (pop. 1,489, ele. 903 A.T., 275 m.). At Kilbourn a trip by boat enables visitors to see the Upper Dells.

gravel, and lake clay, thus showing that an old, southeast-trending valley of Dell Creek lies buried beneath the terrace.

Insert P 13a

From the outwash terrace east of Kilbourn the route eastward again crosses the terminal moraine and also two recessional morainal tracts between which are extensive marshes. The west-dipping, cross-bedded morainal gravel appears to have been deposited in water ponded over the lowlands forming a lake to which Thwaites has given the name, Glacial Lake Oshkosh. As the ice front retreated this lake was extended north and east down the Fox River Valley. It persisted until the escarpment east of Green Bay was so far cleared of ice as to open a lower outlet eastward to the Lake Michigan basin. When this lower outlet was again blocked by a readvance of the ice at the late Wisconsin substage, the lake waters again crossed the col at Portage, cutting it down from 825 A.T. to 796 A.T. (252 m. to 243 m.).

Portage (pop. 6,308, ele. 811 A.T., 247 m.). At this place is a monument marking the point where, in June, 1673, Sieur Joliet and

Pere Marquette launched their canoes on Wisconsin River after their portage of "2700 paces" across the flat from Fox River. A levee now prevents the Wisconsin from overflowing to Fox River at flood stages. For many years a canal and locks were maintained between the two streams, but the shifting sands in the channel of the Wisconsin and other conditions were not favorable to navigation. East of Portage for a long distance the route traverses undulating ground moraine which overlaps the dissected western parts of the Ordovician formations, the "Lower Magnesian" dolomite, the St. Peter sandstone, and the Beloit and Galena dolomites. The eroded edges of the dolomites do not everywhere form definite escarpments in this region. Several miles north of this ~~p~~ hway some knobs of Archean granite, rhyolite, and porphyry rise above the eroded surface of the surrounding Cambrian sandstone.

A few miles east of Portage are small drumlins parallel to the direction of the westward-moving ice. Fifteen to twenty miles (24 to 32 km.) farther east the route ~~north of the margin of~~

passes a mile or so north of the margin of the main area of the famous Wisconsin drumlins (Pl. IV). The trend of the drumlins in this vicinity is southwesterly, the product of the sector of the radially spreading Green Bay lobe which terminated south of the Baraboo Ranges.

Fox Lake (pop. 901, ele. 885 ft., 270 m.). The lake lies in a reentrant of the limestone escarpment and east of a narrow section of the Green Lake recessional moraine. Ten miles farther south the basin of Beaver Dam Lake is closed by a drumlin (Alden 3, p.41). Northeast of Fox Lake the ground moraine overlies the Galena dolomite.

Waupun (pop. 5,768, ele. 888 ft., 271 m.). One of the best examples of planed, polished, and striated surfaces of flat-lying limestone observed was at Randall's quarry at Waupun. On several streets in the city the walks are largely composed of these finely glaciated flagstones, and they are said to have been used in the construction of cells in the first penitentiary building. (Alden 3, p.204).

North and east of the city are patchy recessional moraine deposits and to the southeast is the great Horicon marsh which occupies a basin closed at the south end by the Green Lake recessional moraine. The innermost of the middle Wisconsin recessional moraines, the St. Anna moraines, is crossed east of the village of Lamartine.

Following a further recession of the ice front and a lowering of Glacial Lake Oshkosh (p.), there occurred a readvance of the ice at the late Wisconsin substage into the basin of Lake Winnebago and in that of Lake Michigan (p.). The limit of Green Bay lobe at this substage is marked by a low, somewhat pitted, morainal ridge of reddish till overlying the middle Wisconsin grayish till. This ridge, which encircles the low plain adjacent to Lake Winnebago, is crossed by the highway 3 to 5 miles (km.) northeast of Lamartine. It was bordered on the south and west by a narrow glacial lake and when the ice front again receded from the ridge the basin within it and also the Fox River valley was reflooded by Glacial Lake Oshkosh[1/] up to the

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1/ See "Glacial Lake Jean Nicollet". (Alden 3, pp. 324-325.)

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level of the col at Portage (796 A.T., 243 m.). There are beaches at levels 795 to 825 A.T. (242 to 252 m.), but not everywhere conspicuous.

Fond du Lac (pop. 26,449) stands on the lacustrine plain not far above the level of Lake Winnebago (ele. 747 A.T., 228 m.). The present lake, the largest in Wisconsin, is about 28 miles (45 km.) long from north to south and 10 miles (16 km.) in maximum width. 1/

1/ See topographic map of Fond du Lac and Oshkosh quadrangles.

Adjacent wells indicate that the rock bottom of the ancient valley in which it lies is 100 to 300 feet below the surface, yet so thick is the filling of drift that the lake is but 20 feet deep. To the east a drift-mantled escarpment, 200 to 300 feet (61 to 92 m.) in height, formed by the west edge of the Niagara dolomite (Silurian) and the underlying Maquoketa shale (Ordovician). (Alden 3, p. 39.) This escarpment extends far to the north and south and along the trough at its base was the axial movement of the asymmetrical Green Bay lobe.

The remarkable regularity of the escarpment here and to the north is probably due to glacial erosion (Martin 34, pp.230-235). Farther south it is indented by several embayments due to preglacial erosion.

From the Lake Winnebago trough the ice of the Green Bay lobe crowded up over the Niagara escarpment and spread southeastward on the upland until it met the westward-moving ice of the Lake Michigan glacier head-on and there was formed the famous Kettle Interlobate Moraine (Pl.).

Two miles east of Fond du Lac is a spit (810 A.T., 247 m.) built out from the east shore of Glacial Lake Oshkosh. The gray drift of the St. Anna moraine (middle Wisconsin) and the nearby margin of the red till (late Wisconsin) lie along the foot of the escarpment rising gradually northward until they curve eastward onto the upland farther north.

The route eastward climbs to the upland (1,000 to 1,100 A.T., 305-336 m.) and for 10 miles (16 km.) runs through a group of drumlins remarkable for the various and abnormal southwesterly trends

of their axes and their unusual forms.[1/] Alden (3, p.250) pointed

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1/ See topographic map of Fond du Lac quadrangle.

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out indications of there having been a readvance of the ice over earlier drift ridges, some of them perhaps recessional moraines with shifted direction of ice movement and partial reshaping of the ridges into their present forms. Thwaites suggests that the ice invading this tract at the early Wisconsin substage may have been that of the Lake Michigan glacier and coming from a source somewhat farther east, and that the southwest-trending ridges were due to its action and that some of these ridges were reshaped by the southeastward-moving ice of the Green Bay lobe of the middle Wisconsin substage. A few drumlins seem to have escaped much alteration; others have had new tails built which trend south; some have two distinct tails; still others conform exactly to the later direction of movement.

Farther east is ground moraine with scattered patches of recessional deposits. At Greenbush the famous Kettle Interlobate moraine,

which is largely wooded, is entered. The topography of this moraine is rugged in the extreme; knobs, ridges, and mounds with a relief of over 150 feet are interspersed with inclosed kettles. In many places the slopes are that of the angle of repose of wet gravel, over 30 degrees. Much of the Interlobate or Kettle Range is wooded. Although it is the highest land between Lake Michigan and the Fox-Winnebago lowland, it forms a water parting in but few places, for there are many breaks through which streams pass. When the margins of the two lobes stood close together, assortment of the material was not good and coarse, ill-assorted bouldery gravels were formed in the re-entrant. When included ice masses and the supporting ice walls melted, irregular ridges, knolls, and cones of gravel were left. The latter are called kames. In a few places the conical hills may represent cones found at the bottoms of moulins; other coarse gravels were doubtless deposited in open crevasses. When the angle widened, new lower outlets were opened for the meltwater and terraces of better sorted gravels were formed. Many ice blocks still survived buried in

the sediments and later melted to form terraces of pitted outwash. (See Thwaites 41, pp. 308-319.) The mapping by Alden (3, pp.304-309 and Pl. III) did not in general attempt to separate till moraines, kames, and pitted terraces although he mapped the larger non-pitted or slightly pitted outwash deposits. Several distinct terrace and drainage channel levels with unconsumed remnants of older higher levels rising above them can be seen along the highway approaching Plymouth. Just west of the city a moraine, largely gravel, marks the western side of the Lake Michigan lobe at the time of formation of the lowest terraces.

Sixth day:—

Plymouth (pop. 3,882, ele. 845 A.T., 258 m.) is at the western margin of the red till deposited by the ~~late Wisconsin~~ Lake Michigan glacier at the late Wisconsin readvance. The highway north to Elkhart Lake (pop. 571, ele. 946 A.T., 289 m.) is on terraced and pitted outwash, with a gray drift moraine on the right. Four miles east of the village the area of the red drift is entered. At the top of the hill west of Franklin a pit exposes the bright red till overlying gravel of a middle Wisconsin recessional moraine. In places the older

deposits were folded by the overriding late Wisconsin ice. The lower reddish drift of the ground moraine to the east is nearly flat. This flatness is due to several factors: (a) clay tills such as the red drift flow when wet and form level plains; (b) much of the red drift overlies older outwash plains, and (c) much of it overlies older lake deposits. The low pitted ridge which the road crosses east of Howards Grove may be an older moraine merely mantled by the red drift.

Following the recession of the Lake Michigan glacier of middle Wisconsin age, and both before and after the late Wisconsin readvance and the deposition of the red till the waters of Glacial Lake Chicago submerged a narrow strip west of the present lake shore line up to the level of the highest or Glenwood Beach (640 ft. A.T., 195 m.).

The route runs northward near the west margin of this narrow lacustrine plain. Partly cemented, stratified gravel exposed below red till in gravel pits at Fisher Creek, north of St. Wendell, may represent the early Glenwood Beach of Lake Chicago, although the gravel may have been deposited in a higher local lake. The route

continues north on the red till.

Manitowoc (pop. 22,963; ele. of Lake Michigan 581 A.T., 177 m.). Owing to the absence of a well-marked shore line and to the lack of topographic maps, the exact extent of the submergence at the Calumet stage (about 620 A.T., 189 m.) in this vicinity is not known. From the city north and northeast a large area was submerged by glacial lake waters.

Just north of the city several pits expose deltaic gravel deposits probably made at the margin of the ice in Lake Chicago. Lake silt and clay, much disturbed by ice push, overlie the deposits, but no till is seen. In places percolating water has carried calcium carbonate from the clay down into the gravel cementing it to conglomerate. In places also beach sand and gravel, probably of the Calumet stage, overlie the folded beds unconformably. The waters of Later Glacial Lake Chicago may have reworked such thin red till as was left on the top of the deltas. The route follows the present lake shore northeastward.

In places the waves of Lake Michigan have caused very rapid recession of the cliffs composed of glacial and lacustrine deposits where not adequately protected by breakwaters.

Two Rivers (pop. 10,382). At this place shores of both Glacial Lake Algonquin (607 A.T., 185 m.) and the Nipissing Great Lakes are represented by cliffs and barrier beaches (photo 12 and Pl.II, and see Goldthwait 10, pp. 57-59, 61-62). North from the city, much of which is on sandy Nipissing lake bottom, the highway runs along a ridge of red till which locally resembles a weak terminal moraine. As no trace of the Calumet beach is known north of Two Rivers, this ridge may mark position of the ice border at the maximum extent of that stage of Lake Chicago.

A buried forest bed exposed in the lake cliff at Two Creeks was discovered by Goldthwait in 1905, later explored to some extent by Thwaites, and last studied in detail by Wilson.[1/]

1/ Wilson, L.R., The Two Creeks Forest Bed, Manitowoc County, Wisconsin: Unpublished thesis, University of Wisconsin, 1931.

Deposits exposed at Two Creeks, Wis.

		Feet	Meter
E.	Glacial Lake Algonquin		
	Clay, red, and yellowish gray, varved, calcareous, found up to about 25 feet above Lake Michigan.....	5	
D.	Late Wisconsin glaciation		
	Till, red, clayey, calcareous, some wood.....	8-15	
	Silt, and clay, red, calcareous, some shells.....	0.5	
C.	Interglacial substage		
	Forest Bed - peat, stumps, logs, branches, etc.	0.5	
B.	Glenwood stage of Glacial Lake Chicago		
	Red clay, sand, and gray silt; top part contains organic remains.....	7-12	
A.	Middle Wisconsin glaciation		
	Till, clayey, gray, calcareous.....	3	

In the forest bed (C) Wilson found spruce and pollen of jackpine, 19 species of mosses and 7 of mollusks. Fungi, mites, beetle excavations on logs, and pollens of several upland plants were also collected. The flora and fauna indicate a colder climate than today, one like that of northern Minnesota at present.

A similar section is also exposed in the pit of the Manitowoc Portland Cement Company at Manitowoc except that no forest bed is present. The elevation of the clay suggests that it was deposited in the Glenwood stage of Lake Chicago.

At both exposures the amount of disturbance due to the late Wisconsin ice varies widely. In places the underlying beds seem to have been buried by lake sediments and little disturbed by glacial push. A few feet away all the sediments below the red till are much folded and contorted. Great boulders of silt, clay, and gravel are found in the red till. Locally masses of vegetal remains have been intermingled, not only with the stratified beds, but even with the basal gray till. The surface on which the forest grew undulates considerably and both north and south of the exposures disappears below lake level.

Besides being evidence of an interglacial substage, the forest bed seems to indicate that there was a low water stage of Lake Chicago between the Glenwood and Calumet stages. (See Alden 3, pp.332-335.)

Return to Manitowoc and go west over the red till. A marked terminal moraine is crossed which is probably of middle Wisconsin age

veneered with red till and cuts in another moraine farther west show the underlying gray till.

Valders (pop. 504, ele. 812 A.T., 248 m.). A quarry shows the relations of the middle and late Wisconsin ice sheets. The hill is a reef of Niagara dolomite mantled with till 5 to 10 feet in thickness. At both the north and south ends of the opening gray till is found beneath the red; in the center only red till occurs. Where gray till is present, the only striae trend approximately south; but where the red till rests directly upon the rock, striae bearing west also occur and locally obliterate the older markings. The latter demonstrate that the ice of the late Wisconsin readvance moved westward, for they are best developed on the east-facing sides of the older grooves. About two miles northwest of this point Alden (3, pp.317-318) discovered striae beneath gray till which he thought indicated a southeasterly movement; in the light of the information now available at Valders, it is plausible, however, to suppose that the movement was northwestward and that the ice of the late Wisconsin readvance of the Lake Michigan lobe extended several miles

farther west than previously mapped. The thin edge of the red till of the late Wisconsin is difficult to trace and its exact limits are hard to determine.

A prominent moraine which is crossed several miles west of Valders was mapped by Alden as a recessional of the Green Bay lobe, but he suggested (Alden 3, pp. 299 and 309) that it may be part of the interlobate moraine. It contains very little, if any, Galena dolomite. Thwaites regards it as the interlobate moraine (middle Wisconsin). The route south to Elkhart Lake passes through the same moraine. It is not certain but that this moraine where first seen has been overridden by the late Wisconsin ice, for red clay and red till are found in some of the kettle holes. Surveys by Thwaites have shown that similar overridden moraines near the border of the red till were little altered. From this moraine north of Kiel the St. Anna moraine of the Green Bay lobe branches off to the southwest. Two miles north of Kiel this is joined by an esker (photo 11).

From Elkhart Lake we pass over pitted outwash terraces to Glenbeulah (pop. 284, ele. 972 A.T., 286 m.).

A large commercial pit at Glenbeulah appears to be in a deltaic kame formed in the reentrant between the Green Bay and Lake Michigan lobes. South to Greenbush the route follows the foot of the west side of the Interlobate.

For 30 miles from Greenbush south to West Bend the route lies almost wholly in the Interlobate moraine and its associated outwash terraces. (See description, p. ; also Alden 3, pp. 269-270, 283, 289-293, 308-309, 1916.) Some wells on the great moraine penetrate 200 to 275 feet (61 to 84 m.) of gravel and sand without reaching bedrock.

Seventh day. - Two very high peaks, one of which is a kame which was probably deposited in a moulin some distance from the open part of the reentrant angle between the two ice fronts, may be seen. These are Sugar Loaf or Pulforts Peak (ele. 1,320 A.T., 403 m.) southeast of Hartford and Holy Hill (ele. 1,361 A.T., 415 m.) which

is surmounted by a Catholic church. South and southwest of North Lake is the famous Oconomowoc lake region which lies in a big embayment in the drift-covered Niagara escarpment due to preglacial erosion. For several miles the Interlobate moraine is not present until it is resumed in Lapham Hill, formerly known as Government Hill (ele. 1,233 A.T., 376 m.). This gap in the moraine is due in large part to the fact that streams fed by the melting Lake Michigan lobe here crossed into the area just vacated by Green Bay ice. Farther south, east of Delafield (ele. 900 A.T.) there are several abandoned stream channels. The one followed by our route seems to have been the latest. It carried water from the ice in the basin of Pewaukee Lake west across a stagnant block in Lake Nagawicka basin, a tributary of the Rock River. At an earlier stage this stream must have gone south through the valley which lies just below the State Tuberculosis Sanitarium and east of Government Hill.

From this region the route goes west into the southeastern part of the great drumlin area. (Pl. IV and photos 9 and 10.)

The drumlins of this vicinity trend slightly east of south, for they were developed by the southeasterly quadrant of the Green Bay lobe. Alden (3, pp. 253-256)[1/] has suggested that the remarkable radial

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1/ Alden, W.C., Radiation of glacial flow as a factor in drumlin formation. (Abstract) Geol. Soc. America Bull., vol. 22, pp.733-734 (1911).

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spreading of the ice in the southern part of the Green Bay lobe may have been an important factor in the development of the drumlins. But few, if any, of the Wisconsin drumlins appear to be built over rock cores. Eskers may be seen in some places between the drumlins. Several poorly developed belts of recessional moraine deposits may be traced transversely across the drumlin area.

As drumlins were not formed within several miles of either the terminal or interlobate moraines, no more are seen beyond a point a few miles south of Rome. Much of the low ground along Scuppernong Creek was the site of a temporary glacial lake until an outlet was eroded through the moraines to the southwest.

From Palmyra (pop. 642, ele. 840 A.T., 256 m.) to Eagle (pop. 392, ele. 945 A.T., 288 m.) the Kettle Interlobate Moraine is recrossed. In digging a well near Eagle one of the few drift diamonds discovered in Wisconsin, a 15 karat stone, was found. From Eagle south is a remarkable series of outwash terraces, all of them pitted, which was explained by Alden 1/ as due to changes in drainage

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1/ Alden, W.C., (3, pp. 267-269, 275-277); also the Delavan lobe of the Lake Michigan Glacier: U.S. Geol. Survey Prof. Paper 34, pp. 44-49, 57-62, 1904.

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outlets as a result of ice recession. The highest terraces were formed when the meltwater from the Green Bay and Lake Michigan fronts escaped to the southwest to Rock River via the Turtle Creek outlet. Later terracing was due to (a) erosion of this outlet and (b) the successive uncovering of two lower outlets to the east via the Fox River of Illinois. Present day exposures indicate that some parts of moraines shown by Alden on his maps of this region are pitted and dissected terraces of sand and gravel, as is also indicated in his text descriptions.

West Bend (pop. 3,378, ele. 900 A.T., 275 m.).

Schlesinger (ele. 1,069 A.T., 326 m.).

Hartford (pop. 4,515, ele. 983 A.T., 300 m.).

North Lake (ele. 900 A.T., 275 m.).

For 35 to 40 miles (56-64 km.) the route southward from the vicinity of West Bend past Cedar Lake traverses the same Kettle Interlobate morainal belt and associated terraces.[1/]

1/ See topographic maps of West Bend, Hartford, Oconomowoc, Eagle, and Whitewater (Wis.) quadrangles.

The route runs westward across the Elkhorn moraine, a recessional of a minor lobe of the Lake Michigan Glacier, known as the Delavan lobe. Where the Interlobate Moraine is recrossed on this route, its southeastern side is buried beneath a great pitted outwash deposit showing that here the Green Bay ice on the west lasted longer than did the Lake Michigan glacier on the east. Its northwest front is steep and 100 to 200 feet (31-61 m.) high. An abandoned railway cut traversed by the road to Whitewater exposes very stony till in the moraine. About 90 per cent of this material is of local derivation. Southwestward to the interlobate angle at Richmond the moraine is broader and more typical in character. At Richmond two great terminal moraines of the middle Wisconsin substage diverge; the Johnstown moraine of the Green Bay lobe extands westward to and across the buried preglacial valley of Rock River; the Darien moraine extends southward in a broad easterly curve marking the limit of a minor lobe of the Lake Michigan Glacier, known as the Delavan lobe. The outer fronts of both of these terminal moraines are bordered by extensive

outwash deposits, somewhat trenched by erosion. From Richmond southward the route closely follows the outer front of the Darien moraine and crosses the terraced valley of Turtle Creek through which water from the retreating glacier front flowed westward. South and southwest of Darien, beyond the outwash terrace, is the rolling ground moraine of the Illinoian drift.

Records of wells, penetrating more than 400 feet of glacial drift in places within the Darien moraine, indicate that there is a broad and deep ~~escarpment~~ preglacial valley west of the drift-covered Niagara escarpment and extending southward between Darien and Elkhorn and under the outwash plain known as Bigfoot Prairie, south of Walworth. In another preglacial valley tributary to this lies the basin of Lake Geneva. One reason for the great thickness of drift, where the Darien moraine crosses the old valley, is that the northward extension of the early Wisconsin terminal moraine (the Marengo Ridge of northern Illinois) may be buried beneath the middle Wisconsin drift of the Delavan lobe.

Oct. 6, 1933

Dr. Anna M. Wellnitz,
90 Elwood Place,
West New Brighton,
Staten Island, New York

Dear Miss Wellnitz:

The photographs ordered by you in your letter of Sept. 8 are enclosed. Hope you find them satisfactory. Some of the earlier ones were underexposed. This is an error I seldom fall into but in the haste of such a trip it may happen! The cost was 6 cents each or $2.10 so I am enclosing 15 cents in stamps. There is no charge for postage.

Since my return I went on the Kansas Geological Society Field Conference in the Ozarks and Boston Mountains. This was a very nice trip made at much less cost per day than the one I went on two years ago with the same group. Since then Mrs. Thwaites and I went down to the Chicago Fair for two days.

The text book of glacial geology is still dormant waiting developments in the Depression. With reduced salaries, higher prices, smaller classes and still hard times all around us things do not look any too rosy hereabouts. But we are carrying on and hoping for better times-someday.

With best regards,

Sincerely,

F. T. Thwaites

R. D. 4, Madison, Wis.
Oct. 6, 1933

Dr. Clarence E. Gordon,
Dept. of Geology,
Massachusetts State College,
Amherst, Massachusetts

Dear Dr. Gordon:

The photographs ordered in your letter of Sept. 27 are enclosed and I hope you will find them satisfactory. The cost was 6 cents each so I am returning the ballance of 23 cents for there is no charge for postage.

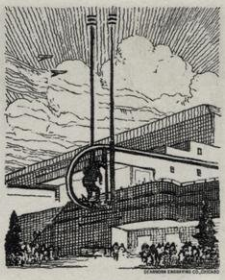
We, too, have been busy with the start of school but my only class this semester is smaller than ever so I am not overburdened. The advanced students have fallen off terribly in numbers. Many have exhausted their funds and have to remain at home and others have turned to different fields. Altogether, with reduced salaries, higher living costs, and the Depression still undiminished about us things do not look any too encouraging hereabouts. But we are hoping for better times, someday.

I deposited the check and have heard nothing from it so assume it went through all right. Thank you.

With best regards,

Sincerely,

F. T. Thwaites



AGRICULTURAL BUILDING WORLDS FAIR CHICAGO 1933

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September 8, 1933.

My dear Dr. Thwaites,

I have just returned from my vacation and find your package of pictures awaiting me. They will prove very useful in my course on glacial geology.

I note that the pictures taken on this last trip are now available. Please send

technique involved in the middle western areas.

I extend my good wishes for yourself and family.

Cordially,

Chas W. Wellenitz.

me at your convenience a complete set. Check is enclosed.

In reviewing the trips taken in connection with the Geological congress, I consider those covering the glaciated territory as most profitable. Accept my thanks for your effort in pointing out the

The Commonwealth of Massachusetts
Department of Education
Massachusetts State College

Please address your reply
to the signer of this letter.

Amherst

DEPARTMENT OF ENTOMOLOGY, ZOOLOGY, & GEOLOGY

Dept 27/33

Dear Professor Thwaites:

When one waits as long as you have for acknowledgment of something sent he might with good reason begin to wonder if the recipient was appreciative. I am, and I thank you for the blueprint and the list of photos taken by you on the C-3 Excursion. I enclose a list of the photos which I would be glad to have, with order for payment.

We have been getting our Educational Ship under sail and I have been busy. I presume you have also kept

out of mischief. Select your own convenience entirely in the matter of photos.

May I express the hope that your family members are well and that you are finding joy in the new arrival.

With best wishes for yourself.

Cordially.

Clarence E. Gordon

If you experience any difficulty in cashing the cheque do not fail to advise me.

C.E.G.

DEPARTMENT OF GEOLOGY

GEORGE F. KAY
ARTHUR C. TROWBRIDGE
JOSEPH J. RUNNER
ALLEN C. TESTER
ARTHUR K. MILLER

THE STATE UNIVERSITY OF IOWA
IOWA CITY

LOCATIONS OF STOPS MADE BY THE INTERNATIONAL GEOLOGICAL CONGRESS BETWEEN FORT MADISON, IOWA AND MCGREGOR, IOWA.

No.1. View across the Mississippi river valley from the northwest rim, in the north side of Fort Madison. Lee county, north side of Fort Madison, in the northeast quarter of section 4, T.67N., R.4 W.

No.2. Sections of loess, Illinoian till, Kansan till, and Nebraskan till with the peat-like organic remains. these were down along the railroad track below Gus Millers. Lee county, Washington township, extending from the southwest quarter of section 28 to near the center of section 33, T.68 N., R.4 W.

784
785

No.3. Illinoian margin as observed from the west side of the town of West Point, Lee county, West Point township, near the center of section 5, T.68 N., R.5 W.

No.4. Nebraskan gumbotil in the valley along the north side of the road. Lee county, Franklin township, middle of the west side of section 1, T.68 N., R.6 W. Another exposure of this gumbotil is in a ravine about 3/8 mile farther west but we did not stop at it.

786

No.5. Abandoned channel of the Mississippi river that used by the river during the duration of Extinct Lake Calvin. This is where the two cars waited for the rest of the group. Wayne station, Henry county, Wayne township, at the intersection of sections 3,4,9,and 10, T.73 N., R.6 W..

No.6. Good exposure showing the different zones of weathering within Kansan till. The photographs in the envelope given you at Fort Madison are of this section. Washington county, Oregon township, southwest quarter of the southeast quarter of section 21, T.75 N., R.6 W..

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No.7. Interurban cut in the west side of Iowa city, along the west side of the Iowa River valley. Johnson county, West Lucas township, in the southwest quarter of the northeast quarter of section 9, T.79 N., R.6 W..

789
790

No.8. Contact of Iowan drift plain with the loess mantled Kansan drift topography, northeast of North Liberty. Johnson county, Penn township, in the southwest quarter of the northeast quarter of section 1, T.80 N., R.7 W..

791
792

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No.9. Loveland loesslike silts in the valley only a short distance northwest of No.8. Here the Loveland with well developed soil is below unleached Peorian loess. Johnson county, Madison township, extreme southwest quarter of section 26, T.81 N., R. 7 W., along Primary 161 at Midriver.

No.10. Kansan gumbotil which shows an old soil zone filled with organic coloring. This is along both sides of Primary 11 in Benton county, Polk township, southwest quarter of section 3 and the northwest quarter of section 10, T.86 N., R.9 W..

Other exposures of gumbotil at which we did not stop were at the first corner west and another at about ½ mile north of this corner.

No.11. Pocket of gravel with the Iowan till, studied a few miles north of Independence. I am not sure of this location but I believe about 4 miles north.

793

No.12. I checked the location of the boulders which Blackwelder studied and gave it to them at Hazleton but I did not keep it myself. It is three or four miles south of Hazleton

No.13. The section observed west of West Union, along Primary 18, has been described in the report on the Pre-Illinoian Pleistocene Geology of Iowa by Kay and Apfel, page 230. Near the middle of the north line of the northeast quarter of section 16, Windsor township(T.94 N., R.9 W.), Fayette county,

Sept. 27, 1933

Dr. Ernst Antevs,
28 Beacon Ave.,
Auburn, Maine

Dear Dr. Antevs:

I am afraid I have been a long time thanking you for the copy of your book on Mount Washington which was sent at time of your letter of September 9. We will certainly look out for some of the phenomena you describe. The photographs were also appreciated and are bing added to my collection.

Early this month I went on the Field Conference of the Kansas Geological Society to the Ozarks and Boston Mountains. It was a very interesting trip and the low railroad fares enabled me to make it for about a third as much per day as a similar trip cost two years ago. I also enjoy meeting the oil geologists. They are so used to being proved wrong by the drill that they have a very liberal attitude on controversial questions. They hope to come to this state next year although that may be postponed.

Work on the glacial geology text is at a standstill while I finish up a few other matters. One of them is a new suggestion with regard to the Finger Lakes, namely that interglacial stream erosion may be the most important factor rather than glacial erosion. Maybe I am all wrong but I am sure that is the only possible explanation of <u>some</u> features of the region.

With best regards,

Sincerely,

F. T. Thwaites

28 Beacon Ave,
Auburn, Maine
Sept 9.

Dear Prof. Thwaites,

Many thanks for the copies of your itinerary and block diagrams and for the pictures. — The block-diagrams are very interesting and instructive.

During the excursion I thought, but forgot, to suggest that you, when opportunities offer themselves, look for frost phenomena in the driftless area. (Several kinds of frost phenomena are discussed in my book on Mt. Washington.)

I enclose a few pictures from the pleasant excursion. Sincerely yours,

Ernst Antes

Sept. 13, 1933

Dr. Irving B. Crosby,
6 Beacon St.,
Boston, Massachusetts

Dear Dr. Crosby:

I wish to thank you for the separate of your paper on "Drainage changes and their causes in the St. Maurice valley in Quebec" which arrived a short time ago. I was particularly interested in your use of geophysical methods to determine depth to rock for I have long dreamed of being able to do this. We recently tried a "magger" on our farm here and it checked exactly with adjacent wells. Other places, however, it failed entirely.

I am just back from the Seventh Annual Field Conference of the Kansas Geological Society which was held in Missouri, Arkansas, and eastern Oklahoma. It was very interesting but naturally was far removed from glacial geology. I always learn a lot from association with the oil geologists who, although they do not call themselves scientists, are some of the keenest users of science that I know.

Very truly yours,

F. T. Thwaites

Sept. 13, 1933

Dr. Ernst Antevs,
28 Beacon Ave.,
Auburn, Maine

Dear Dr. Antevs:

I wish to thank you greatly for the copy of your book on Mount Washington and the separates of your papers on maps of the Pleistocene glaciations and the Smithsonian report extract. All were much appreciated.

I am just back from the Seventh Annual Field Conference of the Kansas Geological Society which was held in Missouri, Arkansas, and eastern Oklahoma. It was very interesting and instructive but naturally did not touch Pleistocene problems. Meantime, the glacial text is not moving toward publication at an appreciable rate. I have had letters from several of those who were on Excursion C-3 and such are still coming in.

School starts in a week and in the time now left I hope to go to the Fair at Chicago. Most of the things planned for the summer have not been done but I still have hopes as my teaching schedule will be light during the first semester.

Very truly yours,

F. T. Thwaites

16-C

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August 31, 1933

Professor F.T.Thwaites,
Geology Department,
Madison,
Wisconsin.

Dear Professor Thwaites;

Many thanks for the text on Glacial Geology which arrived by mail the other day and which will I know be read with great interest.

The last day of our excursion at Walworth, Wisconsin I took the enclosed pictures which because they include yourself you may wish to add to your collection.

With many pleasant recollections,

Robert H. Merrill.

Sept. 12, 1933

Mr. Robert H. Merrill,
Spooner and Merrill,
Consulting Engineers,
Powers Theatre Building,
Grand Rapids, Michigan

Dear Mr. Merrill:

I wish to thank you for yours of August 31 with enclosed separate of your paper and photos. I am very pleased to add these to my collection.

Since going on the Glacial Geology excursion I have been on the Seventh Annual Field Conference of the Kansas Geological Society in Missouri, Arkansas, and eastern Oklahoma. This I found a most interesting and profitable trip. You may be interested that they intend to come to Wisconsin next year, that is if times improve enough so as to get out enough to make it worth while the expense of getting ready. I thought that you might possibly be interested in going if this is put through.

Very truly yours,

F. T. Thwaites, Lecturer in Geology

DEPARTMENT OF
REGISTRATION AND EDUCATION
M. F. WALSH, DIRECTOR
SPRINGFIELD

STATE OF ILLINOIS
STATE GEOLOGICAL SURVEY DIVISION
M. M. LEIGHTON, CHIEF
305 CERAMICS BUILDING
UNIVERSITY OF ILLINOIS CAMPUS
URBANA

16C

August 15, 1933

Professor F. T. Thwaites
Department of Geology
University of Wisconsin
Madison, Wisconsin

Dear Professor Thwaites:

In accordance with our understanding during the recent C-3 Excursion of the International Geological Congress I am sending you under separate cover the following reprints of various papers dealing with Pleistocene problems:

"Weathered Zones of the Drift Sheets of Illinois" by M. M. Leighton and Paul MacClintock. Reprinted from the Journal of Geology, Vol. XXXVIII, No. 1, January-February, 1930.

"The Peorian Loess and the Classification of the Glacial Drift Sheets of the Mississippi Valley" by M. M. Leighton. Reprinted from the Journal of Geology, Vol. XXXIX, No. 1, January-February, 1931.

"The Naming of the Subdivisions of the Wisconsin Glacial Age" by M. M. Leighton. Reprinted from Science, February 10, 1933.

"The Mechanical Analysis of Fine-Grained Sediments" by W. C. Krumbein. Reprinted from Sedimentary Petrology for December, 1932.

"Textural and Lithological Variations in Glacial Till" by W. C. Krumbein. Reprinted from the Journal of Geology, Vol. XLI, No. 4, May-June, 1933.

Feeling that they might also be of interest to you, I am including with the above a copy of a pamphlet descriptive of our research program here at the Survey, issued at the time of the dedication of our new mineral research laboratories, and a copy of the addresses presented before the Coal Section at the First Annual Mineral Industries Conference of Illinois, held in Urbana last March.

Cordially yours,

W. H. Voskuil

Chief