University of Wisconsin-Extension

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GLACIAL GEOLOGY OF PART OF VILAS COUNTY, WISCONSIN

by

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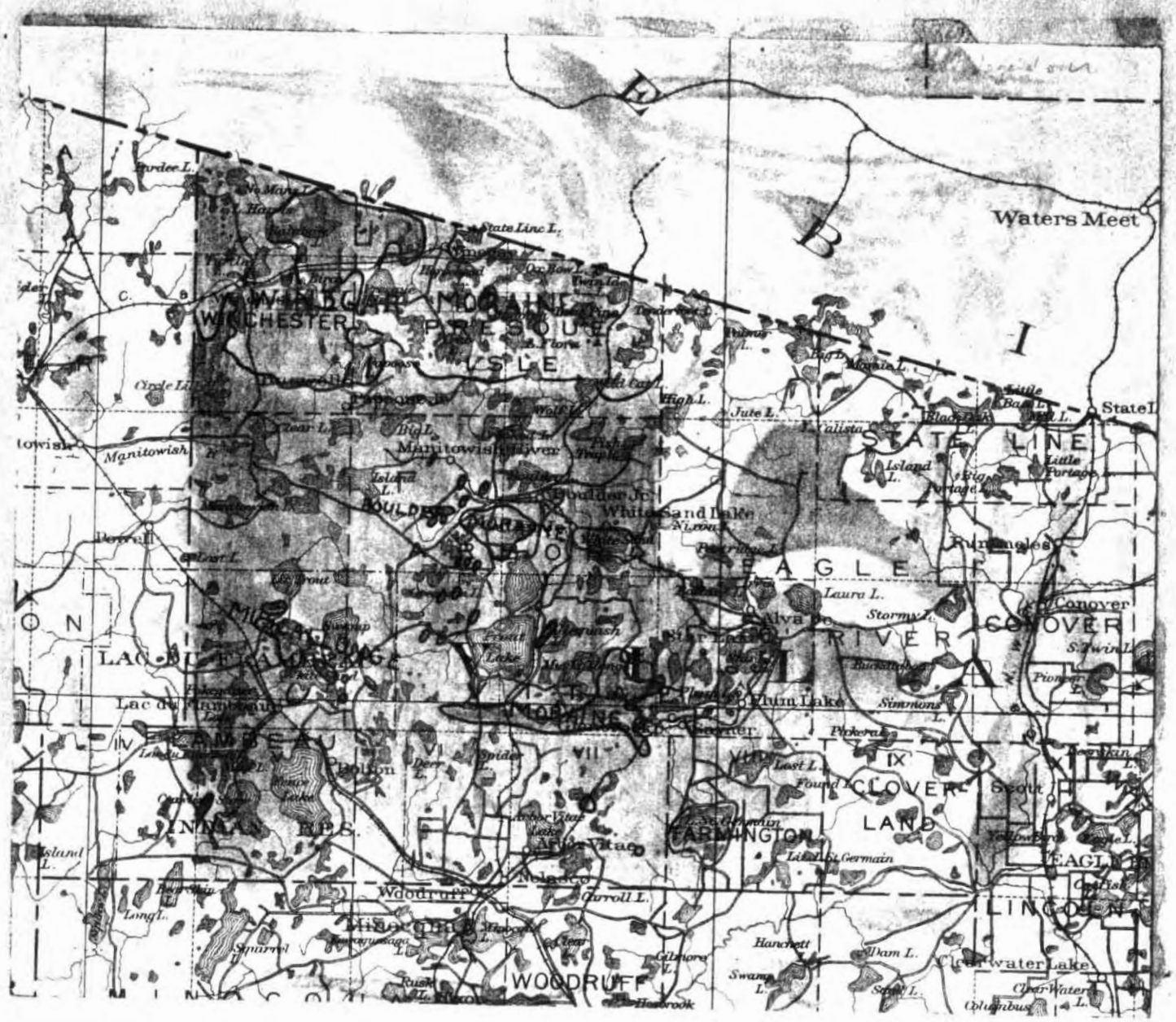
INTRODUCTION

History of investigation.- In 1908 the writer was requested by E. A. Birge, then Director of the Wisconsin Geological and Natural History Survey, to commence a study of the glacial geology of Vilas and adjacent counties, in other words the northern lake region of Wisconsin. At that time funds were insufficient to allow assistance and transportation facilities within the area were limited to a few railroads and to canoe routes, for there were virtually no roads. After discussion with Samuel Weidman and others the project was dropped. In 1927 the matter was taken up again and work was begun on September 23 with the assistance of R. J. Koplin. The termination of the work on October 30 was a few days sooner than had been anticipated but was forced both by the writer's illness and the presence of a case of contagious disease at the field headquarters. The long delay in the commencement of the work was really a great benefit since in the interval the writer has learned so much about glacial geology that by comparison the work done in 1908 would have been of very little value.

Area surveyed.- The area surveyed (map and Pl. I, p. 2) comprises a district north of the south line of Township 40 which covers all of Ranges 5, 6, and 7, as well as a part of Range 8 East. On account of the diagonal location of the state boundary, this area

PLATE I



GLACIAL GEOLOGY OF PART OF VILAS COUNTY

WISCONSIN DRIFT

Terminal moraine

Drumlin

Outwash

Ground moraine

Esker

Surveyed by F. T. Thwaites, 1927

Scale 1 inch = 6 miles

comprises only about 14 1/2 townships or approximately 522 square miles.

Methods.- In considering methods it must first be realized that the study of glacial geology is primarily a study of topography and only secondarily a study of material. The best work can be done where the country is best seen, for views are more important than exposures, although the latter can by no means be neglected. This means that work is done preferably along roads and railroads and is at its best where extensive views of the surrounding territory are available. Since such are best when the leaves are off the trees, it was judged advisable to make the survey in the fall although in 1927 the leaves remained on to an unusually late date. Even after the leaves are almost gone, however, the density of the brush in many places severely limits the field of observation. A disadvantage of the late season in such a northerly latitude is the shortness of the days, but in spite of this work was carried out fairly rapidly, for about 12 square miles were covered every day. Work was carried on seven days a week except when prevented by weather. Most of the time was spent in traversing roads, many of which were formerly logging railroads. Since the trees along the shores of lakes nearly everywhere prevent accurate determination of the shore topography, the use of boats was limited to transportation across lakes. A Chevrolet coach was used in place of the Ford which had formerly been used in glacial work. Although this car has a lower road clearance, its greater power and certainty of control offset this disadvantage and made it a great improvement over the old Model T. No damage resulted from the occasional encounters with stumps and although kept outdoors there was never any difficulty about starting. The party lived at the "State House" or

State Park Headquarters. This proved only an indifferent living place in the fall on account of lack of any privacy, poor light, double deck beds, and drinking water of questionable quality.

Base maps.- The greatest single difficulty encountered by the geologist in Vilas County is the extreme inaccuracy of all maps. Unless funds are available to survey a new map with instruments of a fair degree of precision, much more time is necessarily spent in finding the location than in observations on the geology. For reasons mentioned above work is much better when carried out on roads and trails rather than by following land lines. The roads and trails nearly all wind so excessively that measurements with the speedometer rarely check well on land lines. To traverse all bends would be a tedious and expensive task and when done would not close on either corners or lake shores. It is stated by men familiar with the district that the subdivision of the townships by the original Government Survey was done by pacing and pocket compass and that the meandering of lakes was nearly all fraudulent. A resurvey is in progress around Crab and adjacent lakes and here corners have been reestablished, but the results of this work have not yet been made public. Corners have also been reestablished near to places where cutting is in progress or is contemplated in the near future and along the boundary of the State Park. The boundary of the latter has recently been cut out to a width of 10 to 20 feet. Elsewhere the discovery of corners is very difficult and requires a greater expenditure of time and effort than seemed justified by the monotony of the geology and the necessity for speed. Local resurveys of lake shores were obtained in the towns of Winchester and Winegar. When the sun is out, the mapping of even a very winding trail can be done with only occasional use of the compass; but when

the weather is overcast, the work is very tedious and often very inaccurate. Such work is best done on foot since the constant jumping out of the car to read the compass is very troublesome and time-consuming. The lack of any definite road system necessitates an excessive amount of back tracking and thus decreases the speed. All things considered, the Soil Map published in 1914 is the best available map. The most economical way to make a new and correct map of this region would undoubtedly be from the air as has already been done for a small area near Three Lakes. Aid was received from J. J. McDonald, State Cruiser at Trout Lake; Clarence Buck, Clerk of the town of Winchester; and William F. Kumschki, Assessor of the town of Winegar. All of these furnished maps of parts of the district which saved a great amount of time.

Elevations.- Profiles of the principal railways were furnished by W. L. Towne, Chief Engineer of the Chicago and Northwestern Railway, and C. F. Loweth, Chief Engineer of the Chicago, Milwaukee and St. Paul Railway. From these, aneroid readings were extended over the entire area with particular attention to the levels of the lakes. The making and reduction of these readings was entrusted to the assistant. After the return from the field all his work was checked over by the writer with the resulting elimination of many inconsistencies. It was also discovered in the course of this work in the office that an error had been made by the writer in 1915 in computing the elevations of the Winegar branch of the Chicago and Northwestern Railway which made the published elevations 67 feet too high. In spite of all work it was impossible to eliminate all errors and some must be accounted for by (a) errors in reading or recording, (b) sticking of the needle, (c) sudden movements of the needle due to jars of the in-

strument, and (d) pocketing of cold air over the lakes. It is believed that the great majority of the results are correct to the nearest 10 feet. Elevations of lakes are shown on the large map.

Costs.- The cost of the field work for the season is apportioned as follows:

Salaries	$485.00 =	37 per cent
Travel - 2,699 miles at $0.08 per mile	231.92 =	27 " "
Living	116.95 =	14 " "
Photography	13.88 =	2 " "
Total	$848.35 =	100 " "

Living cost per day	$3.00
Total cost per square mile	about $1.63
Days spent in field work	32
Square miles per day	16.3+
Total days away from Madison	38
Cost per day	$22.00+

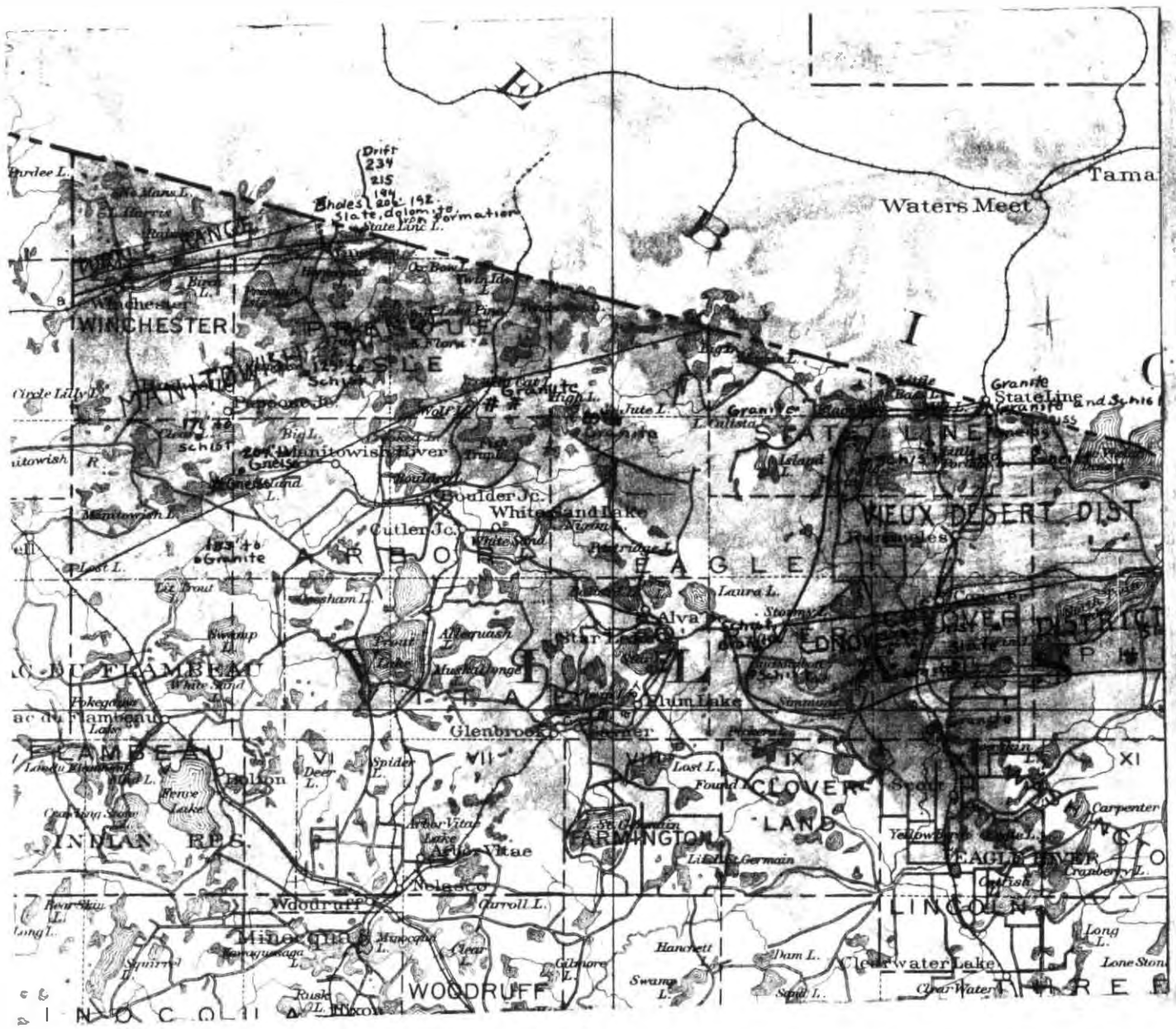
BED ROCKS

Outcrops.- Vilas County is nearly devoid of outcrops, only three are known in the region surveyed, Plate II (p. 7). Two ledges in sec. 34 and 35, T. 43, R. 7 E., northwest of High Lake, were visited by the writer; the rock is a coarse gray and pink granite with pegmatite dikes. The exposures are in a pitted outwash plain although erosion by glacial streams doubtless had a part in uncovering the rock. Allen and Barrett[1] report a ledge of gneiss between Spider and Island lakes which was not visited by the writer.

Drill holes.- During the late panic over iron ore reserves the area was explored by Allen and Barrett for the F. I. Carpenter syndicate. The general results of this work have been published but not the

[1] Allen, R. C., and Barrett, L. P., Contributions to the pre-Cambrian geology of northern Michigan and Wisconsin: Michigan Geol. and Biol. Survey Pub. 16, pp. 69-130, 1915.

PLATE II



BED ROCK GEOLOGY OF VILAS COUNTY

Sediments (quartzite, slate, dolomite, iron formation) ☐

Schist and gneiss (mainly altered sediments) ▨

Granite and pegmatite ☐

Outcrop #

Drill hole •

Based on work of Allen and Barrett for Carpenter Syndicate

Scale 1 inch = 6 miles

detailed logs of the numerous drill holes. The accompanying sketch map (Pl. II, p. 7) summarizes their findings. No exploration is now going on and it is reported that some of the lands which were purchased have since been sold. The drill holes were for the most part on magnetic lines and found granite, quartzite, slate, iron formation, and various types of schist. Few of the published logs give the depth of drift, but this data was secured from the files of C. K. Leith. In this area it varies from 129 to 234 feet. The relief of the bed rock surface is, therefore, not great. The explorers named some of the concealed ranges of much altered iron formation; that which passes through the village of Winegar is the Turtle Range and the much more irregular magnetic belt south of it they called the Manitowish Range. The latter seems to be underlain solely by schist and gneiss. The prevailing strike of folds and schistosity is about N. 70° E.

Inferences from drift.- Virtually no unassorted glacial drift is found in Vilas County south of the latitude of Crab Lake. This fact renders conclusions as to the character of the bed rock rather difficult to arrive at since a large part of the material of the drift may have been transported considerable distances by water in addition to its journey by ice. The transportation by water also removed most of the fine material derived from slates, shales, and soft iron formation. The pebble and bowlder counts show that pink and gray granites and pegmatites, many of which are probably local, predominate. Basalt, both dense and amygdaloidal, diabase, rhyolite, red sandstone, and red shale, all obviously derived from the Keweenawan rocks to the north, make up a large part of the pebbles. There are very few fragments of quartzite and iron formation. The fine material is in large part quartz sand which in the till is mingled with a considerable amount of red clay probably derived from the red Keweenawan and Huronian rocks to the north. It is not at all probable from this data that any large areas of Huronian

rocks exist in Vilas County. The drilling showed that such as are present are much altered by intrusive granites as well as by regional metamorphism. It is highly doubtful that any areas of merchantable iron ore can exist in the area surveyed. The writer is convinced that the bulk of the bed rock is granite and gneiss. The immense amount of sand came from the Keweenawan or Cambrian sandstones to the north.

TOPOGRAPHY

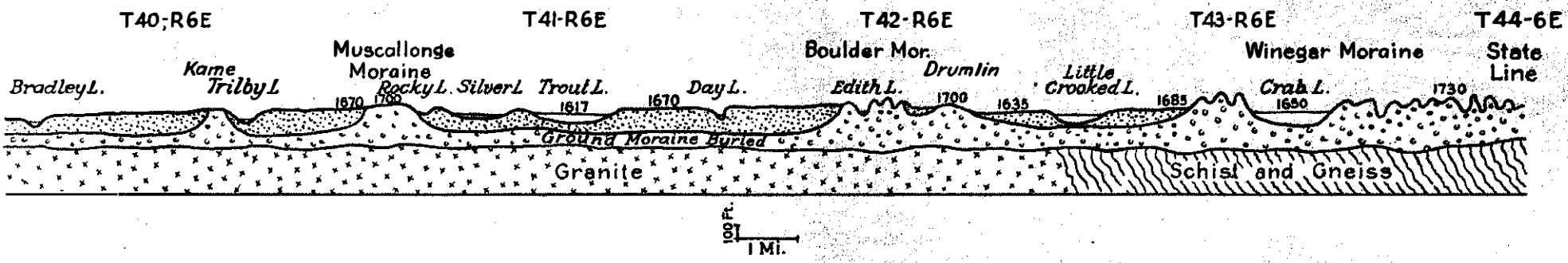
Elevations.- The highest known point in the area surveyed is the hill on which Manitowish Fire Tower is situated (sec. 34, T. 41, R. 7 E.) which reaches an elevation estimated at 1825 feet above sea level. The lowest measured point is Sishebagama Lake in T. 40, R. 5 E. at 1665 feet. The general surface of the country declines from about 1700 feet at the northeast to about 1600 feet in the southwest; 1650 feet is a general average for the country surveyed.

Relief.- Vilas County is a region of relatively low relief (Pl. III, p. 10). Local differences of elevation of much over 50 feet are not at all common although on the other hand extensive flats are rare. The roughest portion of the area is at the north. Here the hills are very irregular both in outline and in summit elevation and local differences of 75 feet are common. Interspersed among these hills are many enclosed basins, a large number of which contain lakes and ponds. This is by all odds the most picturesque portion of the area. Farther south the landscape is a broken plain which offers much more monotonous scenery. Locally small hills and ridges rise above the general level. The lakes and swamps are set in partially or wholly enclosed depressions

North~South Section

One mile west of East line of R.6 showing moraines and outwash plains

▒ = Till and Coarse Gravel ▒ = Outwash ▒ = Granite ▒ = Schist and Gneiss



Profile of Abandoned Logging Railroad

West of Boulder Jct. showing Outwash Terraces. Distances in hundreds of feet.

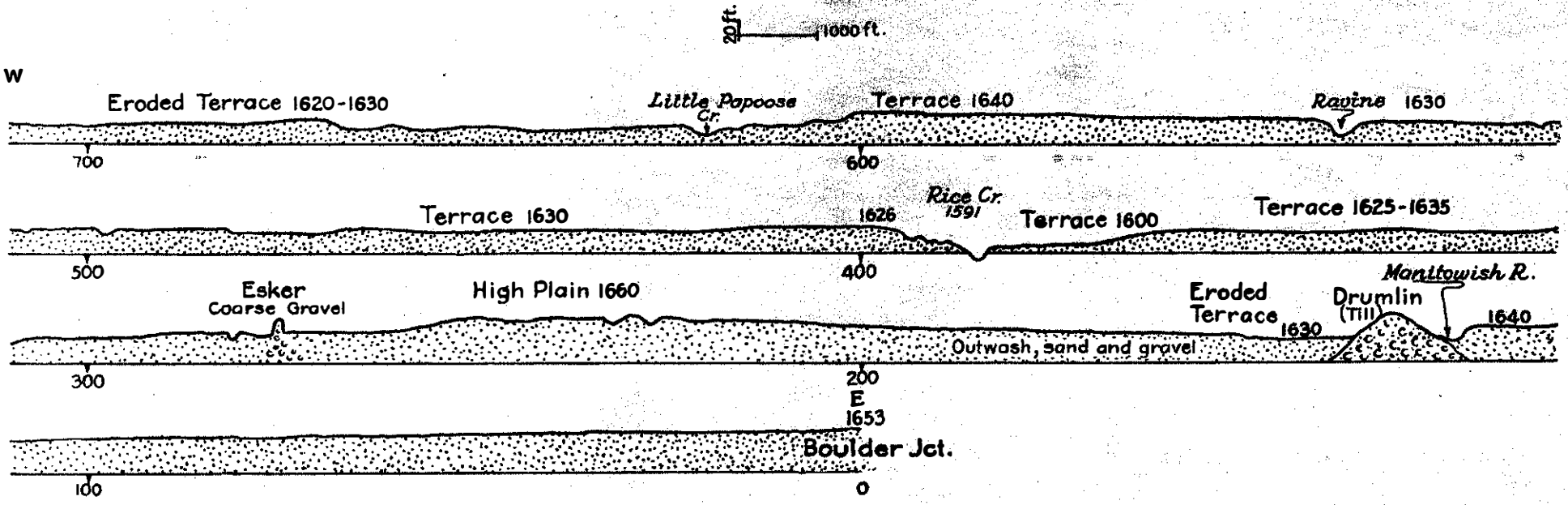


PLATE III

which range from a few feet to 50 feet in depth. Most of the lakes are shallow and small; Trout Lake is the largest and deepest. The total depth of its depression is about 150 feet[2].

DRIFT DEPOSITS

Introduction.- Vilas County is remarkable for the monotony of the glacial geology, that is for the large size of the individual areas of the same origin (Pl. I, p. 8, and map). It is also noted for the simplicity of the geology and the lack of features with a complex glacial history. In spite of this fact, the geologist is compelled by the lack of extended views to traverse the region rather fully lest some relatively small feature escape him and thus make his rendering of the story incomplete. An effort was made to visit every section unless obviously all swamp or all plain.

Types of deposits.- The drift deposits of the area surveyed can be divided into (a) outwash, (b) terminal (recessional) moraines, (c) drumlins, (d) ground moraine, and (e) eskers. Of these, the first covers by far the largest portion of the region and the second forms the most conspicuous topographic features and the most striking country. The other features cover only an inconsequential percentage of the region.

Outwash.- The most widespread and characteristic drift deposit of the lake region of Vilas County is outwash which contains numerous kettles, that is pitted outwash[3]. The material is nearly all horizontally bedded sand which for the most part contains scattered pebbles and

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[2] Birge, E. A., and Juday, C., The inland lakes of Wisconsin: Wisconsin Geol. and Nat. Hist. Survey Bull. 27, p. 129, 1914.

[3] Thwaites, F. T., The origin and significance of pitted outwash: Jour. Geology vol. 34, pp. 306-319, 1926.

a few bowlders. Some small cross bedding is generally present. Fairly well sorted, locally very bowldery gravels are present in some places. The topography varies from level as southwest of Boulder Junction (fig. 1, p. 13) to so much pitted that no upland is left between the kettles; this last type is well shown in the vicinity of Witches Lake west of Sayner (fig. 3, p. 13). In many places the uplands between the kettles are small but when the geologist stands on one he can see at once that the other summits form the remnants of a once continuous plain (fig. 3, p. 14). Many of the kettles extend below the water table and therefore contain marshes or lakes. The majority of the lakes of Vilas County are of this origin. They have low sandy and in most cases uninteresting shores. In the very much pitted areas the resemblance to terminal moraine is striking, especially where bowlders are present (fig. 4, p. 14). Discrimination is not difficult, for in such cases neither the coarse gravel nor clayey till of terminal moraines is present. In many places the deposits are terraced into two or more distinct levels, all pitted (Pl. III, p. 10). It proved impracticable to map the distribution of such terraces over any extended area because of the lack of accurate topographic maps.

Terminal moraine.- Terminal moraine topography consists of knobs with intervening sags; there is neither a level upland nor an equality of summit levels (fig. 5, p. 15). The terminal moraines form elevations above the adjacent outwash areas. The material of the moraines consists of glacial till, ill-assorted gravel (fig. 6, p. 15), sand, and red clay. Bowlders are conspicuous in most terminal moraine areas. Where the land is still covered with virgin timber with its accompanying vegetable mould and fallen leaves they are not easily seen. Three distinct moraines, and traces of a fourth have been discriminated as shown on the accompanying map (Pl. I, p. 2). Of these only the northernmost,

Figure 1.- Non-pitted outwash plain southwest of Boulder Junction. SE. SE. 19, T. 42, R. 7 E. (Photo 4041)

Figure 2.- Muscallonge Fire Tower hill, a kame of the Muscallonge Moraine rising above excessively pitted outwash in vicinity of Witches Lake. SE. SW. 35, T. 41, R. 7 E. (Photo 4032)

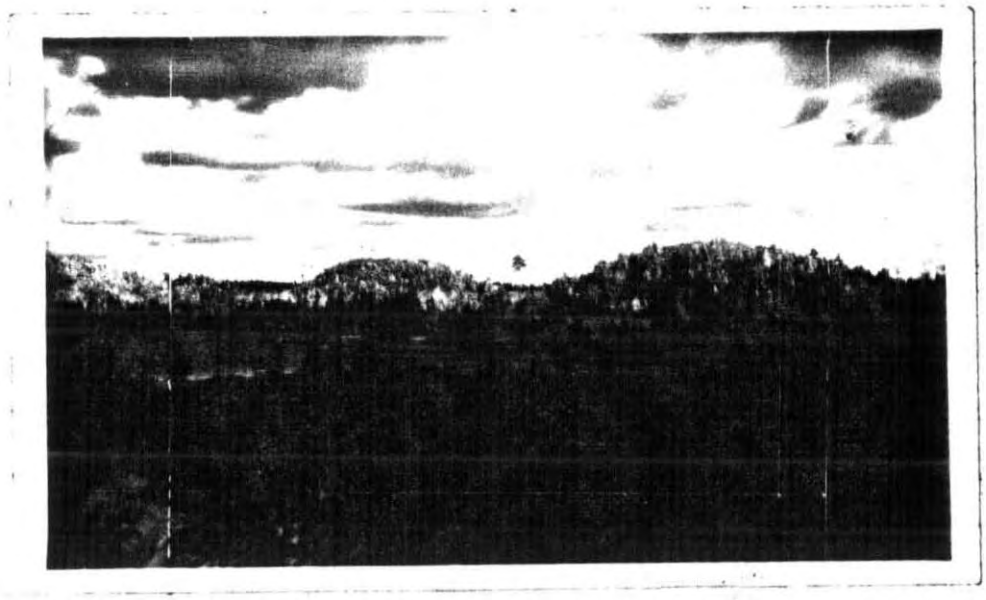

Figure 3.- Mesa-like remnants of excessively pitted outwash near Bear Lake. SE. NE. 24, T. 41, R. 7 E. (Photo 4027).

Figure 4.- Big granite bowlder in eroded outwash. The woods conceal a higher terrace. The bowlder was probably derived from a buried moraine as it is too large to have been ice rafted. NE. NW. 7, T. 41, R. 8 E. (Photo 4036)

Figure 5.- Winegar Moraine near State Line Lake showing excessively rough topography. SW. NW. 35, T. 44, R. 6 E. (Photo 4057)

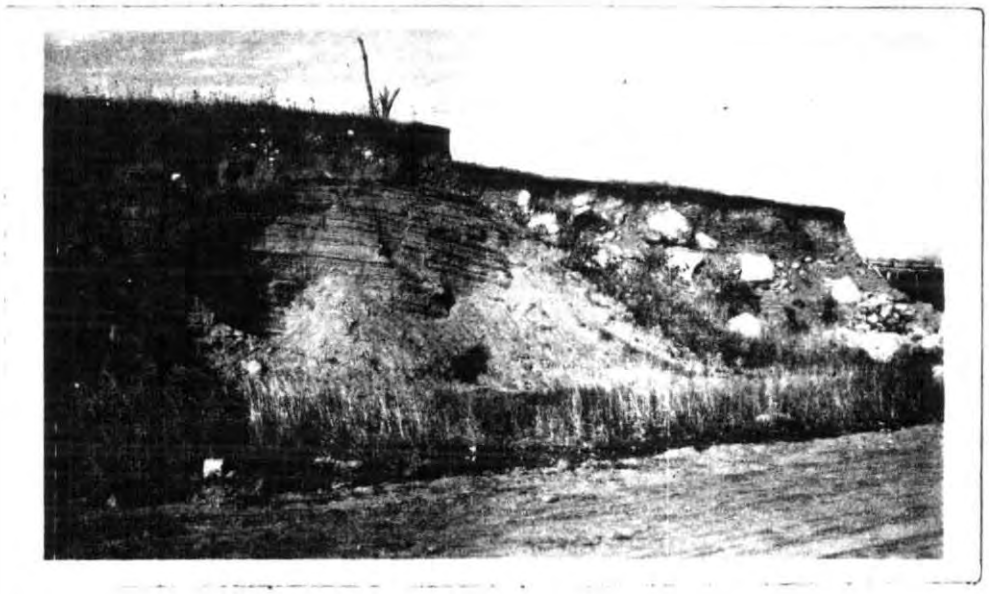

Figure 6.- Kame gravel at Winchester showing very poor assortment and faulting. NE. NW. 8, T. 43, R. 5 E. (Photo 4043)

the Wisconsin moraine, contains a large amount of till. This till is red in color and contains pockets of bouldery sand and red clay (figs. 7 and 8, p. 17). Locally the surface is covered with a few feet of pebbly sand. The red till is bleached to a yellowish gray to depths of several feet from the surface. Lakes are abundant in the kettles and some of the finest bodies of water in the area, such as Crab Lake, are found in this moraine. The other moraines, the Boulder and the Muscallonge, are, as far as could be discovered, composed wholly of assorted material. They can be distinguished from the adjacent outwash by the great abundance of boulders, the coarseness and ill-assortment of the gravels, and by their topographic form of ridges transverse to the direction of glacial movement. Both of these moraines are discontinuous and are represented in some places by isolated knolls of bouldery composition which rise from the adjacent outwash plains.

Drumlins.- Drumlins were not known in this portion of Wisconsin previous to the present survey but had been found in Iron and Gogebic counties, Michigan, by Leverett[4] so that their discovery should excite no surprise. Mapping of drumlins is exceedingly difficult in forested country and it is possible that more drumlins might be recognized were conditions more favorable for observation. It is probable that many other drumlins lie buried beneath the outwash plains from which only the highest project (fig. 9, p. 18).

The mapped drumlins lie west and northwest of Trout Lake with a single outlying specimen just south of Highway 70 in T. 40, R. 5 E. Of these, the latter may very well be a portion of a group most of

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[4] Leverett, Frank, Surface geology and agricultural conditions of Michigan: Michigan Geol. and Biol. Survey Pub. 25, Plate I, 1917.

Figure 7.- Cut in bowldery red till west of Winegar. SW. SW. 34, T. 44, R. 6 E. (Photo 4056)

Figure 8.- Red clay and sand in kettle of Winegar Moraine deposited while ice masses still survived. SW. SE. 34, T. 44, R. 6 E. (Photo 4053)

Figure 9.- Drumlin at Manitowish Fire Tower with outwash in foreground. NW. NW. 24, R. 42, R. 6 E. (Photo 4039)

Figure 10.- Esker showing old railroad cut. NE. SW. 10, T. 42, R. 6 E. (Photo 4037)

which lies south of the area mapped, for drumlins rarely occur alone. It also seems possible that the stony ridge in the so-called Game Farm east of Trout Lake may be a drumlin. The recognized drumlins range from less than a quarter of a mile in length to over three quarters of a mile. The width varies from a third to a quarter of the length. The maximum known height is about 100 feet. Some of the most accessible and perfect drumlins are situated west of Boulder Junction near the Manitowish Fire Tower. All the observed drumlins have a trend of 30 to 40° west of south.

Ground moraine.- No true ground moraine, that is thin, rolling drift through which the older rock topography shows, is present in the area surveyed. An area southeast of Big Papoose Lake in T. 43, R. 6 E. is bouldery, gently rolling, and is apparently underlain by till. It was mapped as ground moraine because of the low relief, but its origin is doubtless associated with the drainage from the ice front at this point which eroded and leveled some of the border of the Wisconsin moraine.

Eskers.- Eskers are the beds of glacial streams which were confined by walls of ice. They consist of relatively low discontinuous ridges of coarse, ill-assorted gravel. The discovery of eskers in a forested region is a matter of chance. Many eskers are probably buried under the outwash and in a few places the ice blocks which formed the kettles served to protect a portion of an esker from such cover. Discrimination of esker remnants from accidental ridges between pits is a matter of examining the material. Unless cuts are present, such examination is very difficult. One of the best eskers which was discovered is that crossed by the old railway grade in sec. 10, T. 42, R. 6 E. (fig. 10, p. 18). It is possible that the ridge of coarse gravel west of Crawling Stone Lake is really a gigantic esker and not a moraine as

mapped. The location of other known eskers is shown on the map.

GLACIAL HISTORY

Introduction.- The glacial history of the region surveyed is, so far as the evidence there observed goes, relatively simple. It tells only of the last, or Wisconsin, glaciation which in this region ended in a relatively rapid retreat of the ice front interrupted by three or four halts. The times of relatively stationary margin resulted in the formation of successive moraines. The comparative durations of the halts may be estimated from the size of the respective moraines; this criterion shows that the formation of the most northerly or Winegar moraine took longest. During each halt floods of water from the melting ice buried the country just vacated beneath their load of sediment.

Direction of ice movement.- The direction in which the glacier moved in Vilas County is shown by (a) the direction of the long axes of the drumlins and eskers, (b) the trend of the terminal moraines, (c) marks on bed rock, and (d) the direction of the long axes of many of the lakes. All of these indicate a motion toward the southwest (about S. 35° W.). The single observed groove on a ledge bears S. 50° W.

Formation of ground moraine and drumlins.- When the ice margin of the Wisconsin glacier stood at the outermost moraine in Lincoln County, doubtless some drift, possibly including some of the drumlins, was deposited. It is possible, however, that these particular drumlins were not formed until the ice edge had melted back some distance, but they were undoubtedly in their present form before the border reached the area surveyed as drumlins are rarely found within ten miles of the farthest extent of an ice sheet. A considerable portion of the unassorted drift or ground moraine was undoubtedly formed during the last

melting of the ice.

First halt of ice margin.- The first record of a halt of the ice margin within the area surveyed consists in some scattered morainic knolls in T. 40, R. 5 E. All these are small and of such character that some might equally well be simply large eskers or possibly in part imperfect drumlins. If any definite moraine was formed, it is now almost wholly buried in outwash.

Muscallonge Moraine.- The halt of the ice margin which allowed the deposition of the Muscallonge Moraine followed upon such rapid melting of the glacier that retirement from the area to the southwest was not complete. In hollows, valleys, and depressions between drumlins masses of stagnant ice from a few feet to two or three miles in width survived just as isolated bodies of troops are left behind during the retreat of a defeated army. Protected only by a mantle of melted-out drift accumulated from their own burden, these would seem have succumbed to the sun's rays; but while the ice margin was at the Muscallonge Moraine, vast quantities of water flowed from the glacier and buried the isolated ice blocks in sand and gravel with scattered bowlders carried by ice bergs. This extra cover prolonged the life of many of the glacial remnants. The material of the moraine itself was also worked over by water. As originaly deposited the moraine rose above the outwash plain to the south in only a few places, notably at the hill where the Muscallonge Fire Tower now stands. Near the moraine this plain had an elevation of about 1700 feet above sea level. It sloped gently toward the south and southwest. The outwash at Lac du Flambeau Station is unusually bowldery and coarse (fig. 11, p. 82). Such stony layers are doubtless present elsewhere and await discovery by deep digging.

Boulder Moraine.- What caused the alternating rapid retreats and periods of relative stability of the ice margin is not known. Certainly

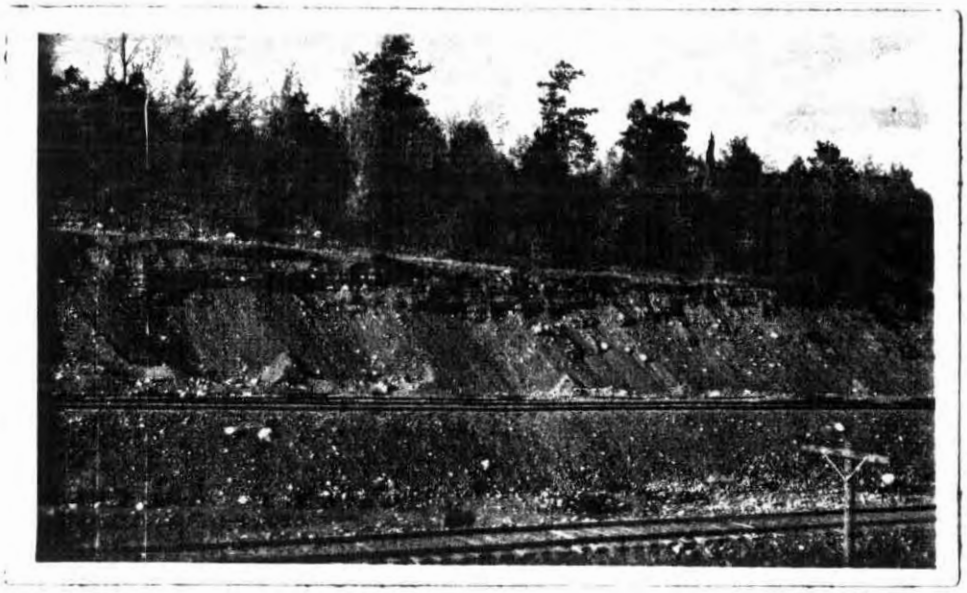

Figure 11.- Chicago and Northwestern Railroad pit, Lac du Flambeau Station, showing coarse bowldery gravel. Bowlders were probably transported in ice bergs. SE. NW. 34, T. 41, R. 5 E. (Photo 4024)

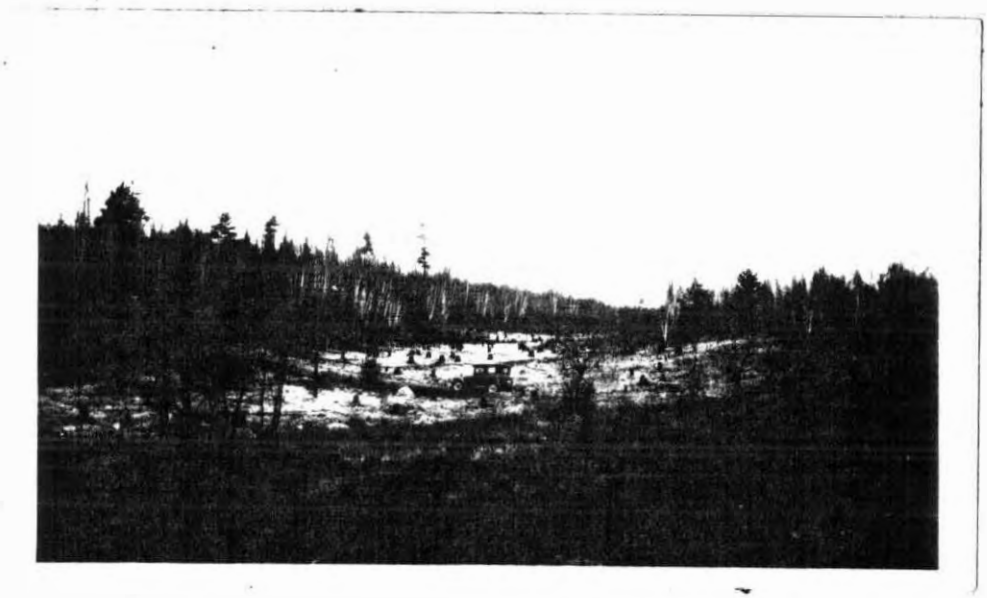

Figure 12.- Eroded glacial drainage outlet in outwash plain showing concentration of ice rafted bowlders. SE. SE. 5, T. 41, R. 8 E. (Photo 4034)

in Vilas County it was not due to melting back to positions where the glacial front was protected by hills although it is true that as a moraine accumulated, it tended to prolong the halt by protecting the ice from the sun. More likely changes either in local climate or in nourishment of the ice to the north were the cause. The Boulder Moraine marks a retreat of about 8 miles and the deposition of an outwash plain which buried blocks of ice up to about four miles long and at least 150 feet thick. Such large blocks may have projected above the sand plain. The deposits buried much of the formerly deposited terminal moraine as well as all the intervening ground moraine and many drumlins. The elongations of many of the ice blocks in a northeast-southwest direction is doubtless explained by their location in low tracts between drumlin uplands, for drumlins occur in groups arranged parallel to the direction of ice movement. Moreover, it is possible that preglacial or interglacial valleys trended toward the southwest. The streams from the new ice front found lower courses than had prevailed when the plain south of the Muscallonge Moraine was completed. In part this was due to lower outlets freed by the recession of the main body of the ice and in part to melting of buried ice blocks in the outwash to the south which opened new drainage lines (fig. 12, p. 22). The result was to cut away a large portion of the high level plain south of the Muscallonge Moraine before all of the buried ice masses had melted, for there are many kettles in the later drainage lines. Large portions of the older moraine were also eroded away or buried under outwash. When the ice blocks melted, the bowlders they contained were deposited in the resulting kettles or pits.

Winegar Moraine.- The formation of the Boulder Moraine was followed by a retreat of about five miles after which a prolonged halt of the border caused the deposition of the big Winegar Moraine. That this

moraine is one of recession and not of readvance is demonstrated by the gradation of the moraine into the pitted outwash south of it. Had the ice front retired long enough to permit melting of the buried ice blocks, unpitted outwash would have been deposited along large portions of the border of the moraine. No such deposits are present. The Winegar moraine contains less water-sorted material than do the other moraines of the area, but there are many kames and several large patches of pitted outwash, probably not all mapped, within the moraine proper. Some of these outwash plains had drainage outlets over blocks of ice which have since melted to form lake basins. Kettles formed when the isolated ice masses which were buried in the till melted; into those kettles which formed before the surrounding moraine was clad with vegetation red clay, fine sand, and some ice-rafted bowlders were washed. In October 1927 a good example of this could be seen just west of the station at Winegar(fig. 8, p. 17). The red color of the clay is probably due to its derivation from red Keweenawan and Huronian rocks to the north rather than to the plowing up of lake clays as in northeastern Wisconsin. The outwash streams from the Winegar Moraine also formed a plain lower than the higher portions of the Boulder outwash plain. The older moraines and outwash plains were extensively eroded and buried. This was done before the ice blocks had all melted. Little was left of the Boulder Moraine. The lower plain may be seen cutting across the higher plains along Highway 51 west of Trout Lake and southwest of Sayner. The main level of outwash from the Winegar Moraine is that seen at Boulder Junction (fig. 1, p. 13). It was itself extensively terraced along Manitowish River by flow coming through the outer part of the moraine when the ice front had retired slightly farther north (Pl. III, p. 10).

Postglacial.- The glacial history of the area closes with the completion of the Wisconsin Moraine, for after that no more glacial drainage seems to have reached this region. This was due to the abrupt northward descent of the land north of the moraine in Michigan which diverted the waters to lower outlets than those across Vilas County. Since the close of glaciation the surface of the land in Vilas County has been altered by (a) erosion along some of the principal streams forming valleys with a maximum depth of 20 feet, (b) organic deposits in lakes and pools forming marshes, and (c) weathering which has kaolinized the feldspar of the sands to depths of one to three feet and has oxidized the iron-bearing minerals to much greater depths. In many places hydrous iron oxide has been redeposited in veinlets to a depth of more than five feet from the surface. These form irregular hard bands on the weathered surface of an exposure. In the red till region the color has been changed by hydration and solution to yellowish brown to a depth of two to four feet from the surface.

ECONOMIC GEOLOGY

Sand and gravel.- Although the largest part of the area surveyed is underlain by outwash and other forms of assorted drift, good gravel is not common. Most of the outwash is fine sand. The best stony gravels are found in (a) outwash close to the moraines, (b) Kames within the terminal moraines, and (c) eskers. The following list of pits is probably not complete, for small excavations near summer resorts may have escaped observation.

Location	Origin	Remarks
T. 43, R. 4 E. Sec. 24	Kame (esker?)	Large pit in poorly sorted gravels
T. 43, R. 5 E. Secs. 8 and 9	Kames	Several small pits in and near Winchester
Sec. 25	Kame	On road to Little Long Lake
T. 42, R. 5 E. Sec. 4	Outwash	Several pits in rather fine sandy gravel along C.T.H. "B"
T. 41, R. 5 E. Sec. 30	Outwash	Roadside pit on new road to Powell
Sec. 34	Outwash	Largest pit in area, 1/4 mile long, 40 feet deep; used for filling by C. and N.W. R.R.
T. 40, R. 5 E. Secs. 18 and 19	Kame or esker	On town road to Flambeau Lake
Sec. 34	Kame	On Bolton road
T. 43, R. 6 E. Sec. 20	Outwash	On road to Crab Lake
T. 42, R. 6 E. Sec. 2	Outwash or kame	On road to Big Lake
Sec. 10	Esker	On Rice Creek road
Sec. 24	Outwash	On tail of drumlin on road to Big Lake
T. 41, R. 6 E. Sec. 17	Kame	On road to Flambeau; in part till
T. 40, R. 6 E. Sec. 14	Kame	Undeveloped cut on U. S. 51
Sec. 19	Outwash	On road to Flambeau
T. 43, R. 7 E. Sec. 27	Kame	Old railway cut on Blue Bill line
T. 42, R. 7 E. Sec. 6	Esker	On grounds of National Playgrounds Association
T. 41, R. 7 E. Sec. 26	Kame	On Sayner-Trout Lake road
Sec. 36	Kame	On Sayner-Trout Lake road
T. 41, R. 8 E. Sec. 27	Kame buried in outwash	On C. T. H. "S"

In addition to the above list there are many pits in the weathered surface of the outwash or "top soil" and a number in such sandy material that its use seems unwise. Many showings of what seemed to be good stony gravel were observed both along roads and in the brush, but as these were not confirmed by digging, they have been omitted. All the gravel is composed of hard crystalline pebbles and a few pebbles of sandstone. The gravels are inferior for both surfacing and concrete pavement to those found in limestone regions.

Water.- Underground water supplies have been developed only to a very limited extent in the area surveyed. The railroad tank at Boulder Junction is supplied from driven wells in the outwash. Many summer resorts have shallow dug or driven wells but others, like the State House, depend upon lake water. It is unlikely that large supplies could be developed at all points as coarse gravel is so scarce. In many places till may be found below the outwash and above the water table; in such situations little water could be obtained from wells. It is likely that considerable iron will be found in the ground water at most localities, for the forest mould and peat swamps undoubtedly dissolve a considerable amount of that substance.

Soils.- The soils of the area here discussed have been described by Whitson, Dunnewald, and others[5] in connection with the controversy over reforestation. The map made for this report bears evidence of much careful and painstaking work but of very limited knowledge of geology. The following table represents the findings of the writer as to the true origin of the several soil series described in the report.

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[5] Whitson, A. R., and Dunnewald, T. J., and others, Soil survey of Vilas and portions of adjoining counties: Wisconsin Geol. and Nat. Hist. Survey Bull. 43, 1915.

Soil Series	Origin
Plainfield	Outwash, little pitted and only slightly weathered
Vilas	Outwash with a few kames and some terminal moraine where the till is covered with a few feet of sand; shows more alteration than the Plainfield soils
Antigo	Outwash, little pitted and considerably weathered
Kennan	Sandy loams, mainly terminal moraine, especially the rolling phase; level phase includes much deeply weathered outwash; silt loams not yet investigated in this area

The statement that a large part of the Vilas soils was deposited directly by the ice is an error which may have been based on misteking pitted outwash for terminal moraine. Exactly why the good level outwash soils at the Brooks and Rose farm north of Wolf Lake should be mapped under the same classification as the rough terminal farther north is not clear. Nor could the writer discern why some of the moraine is called "rolling" and other parts level. The writer is convinced that a knowledge of glacial geology on the part of the soils men would not only have resulted in a better map, but it would have saved much time in field work by allowing intelligent interpolation between traverses and of better correlation of the results of the several field workers.

CONCLUSION

General.- Although the present survey covered only a portion of the northern lake region, it is believed that it showed the general type of geology which exists throughout the area. Work over a much larger area will be necessary to connect the moraines into the general history of the recession of the Wisconsin ice sheet, but the problems of the origin of the lesser topographic features such as the lakes have been solved.

- F. T. Thwaites, January 17, 1928