GLACIAL GEOLOGY OF PART OF VILAS COUNTY, WISCONSIN[1]

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INTRODUCTION

This study of the glacial geology of part of Vilas County, Wisconsin, was begun on September 23 and was terminated on October 30, 1927. The area surveyed is shown on the accompanying map (fig. 1). It comprises Townships 40 to 44, inclusive, and all of Ranges V, VI, VII and part of Range VIII East. On account of the diagonal location of the state boundary, this area includes only about fourteen and a half townships, or approximately 522 square miles. Many lakes and lakelets are situated within the area and this study of the glacial geology of the region was carried out in connection with an extended physical, chemical and biological investigation of these lakes. Only a few of the larger lakes are shown in figure 1.

A study of glacial geology is primarily a study of topography and only secondarily a study of material. Extensive views of the surrounding territory are, therefore, of chief importance, though exposures can by no means be neglected. Since most of the region is covered with second growth timber, this survey was made in the autumn after most of the leaves had fallen from the trees; even after the leaves are almost gone, the density of the brush in many places severely limits the field of observation. Work was done preferably along roads and railroads, especially where extensive views of the surrounding territory were available. About 16 square miles per day were covered in the survey.

All of the maps of the region are extremely inaccurate owing to inaccuracies in the original Government Survey. Thus much more time must be spent at times in finding exact locations than in making the observations on the geol-

[1] Published by permission of the State Geologist.

ogy. Resurveys are being made in some parts of the area and eventually more accurate maps will be available.

Acknowledgments. Aid was received from J. J. McDonald, State Cruiser at Trout Lake; Clarence Buck, Clerk

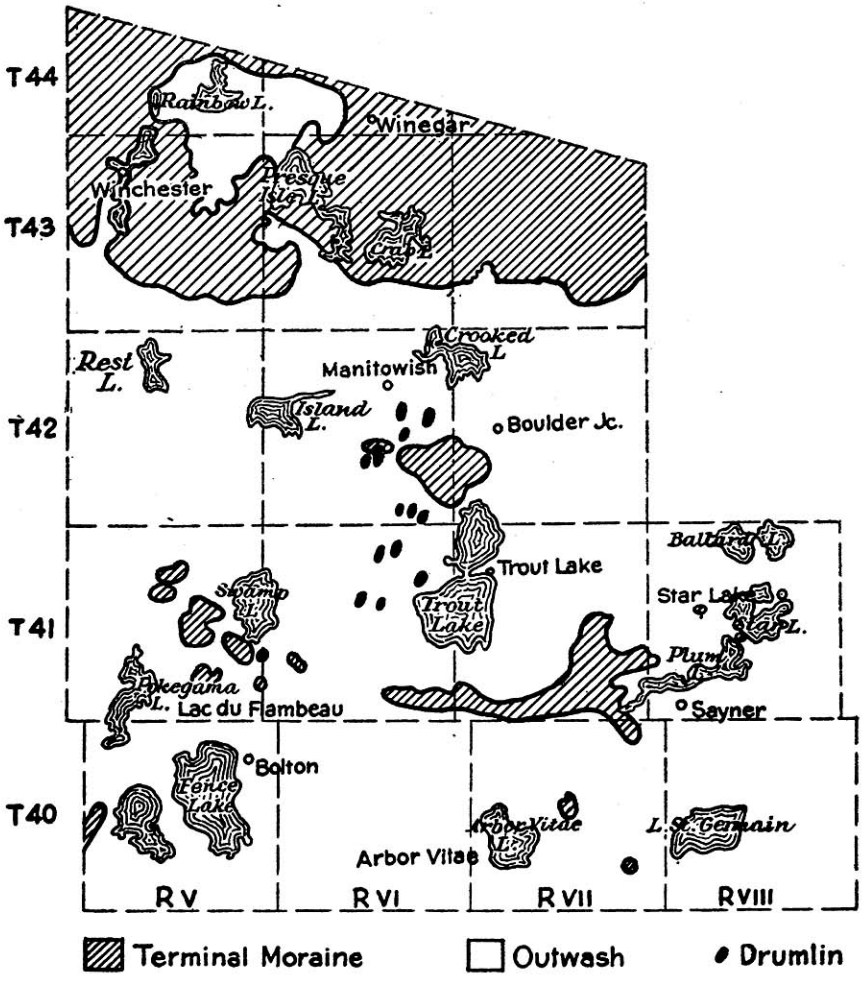

FIG. 1.

of the town of Winchester; and William F. Kunschki, Assessor of the town of Winegar. 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, St. Paul and Pacific Railroad.

Elevations. From the railroad profiles as a base, aneroid readings were extended over the entire area, with particular attention to the levels of the lakes. Great care was used in making these readings and it is believed that the great majority of the results are correct to the nearest 10 feet. Table 1 shows the results of these observations.

TABLE 1. *Elevations of lakes in Vilas County, indicated in feet above sea level.*

Lake	Town No.	Range E.	Elevation
Alder	42	V	1600
Arbor Vitae	40	VII	1605
Armour	43	VI	1645
Ballard	41	VIII	1670
Bass	42	VI	1635
Bass	41	V	1615
Bear	41	VII	1645
Big	42	VI	1600
Birch	43	V	1635
Boulder	42	VII	1625
Carlton	43	VI	1650
Clear	42	V	1590
Clear Crooked	42	VII	1630
Crab	43	VI	1655
Crawling Stone	40	V	1570
Crooked	41	V	1620
Dam	42	V	1580
Day	41	VI	1625
Edith	42	VI	1630
Fence	40	V	1590
Fishtrap	42	VII	1640
Flambeau	40	V	1570
Found	40	VIII	1630
Grassy	42	VII	1650
Gresham (Upper)	41	VI	1605
Gunlock	40	V	1575
Halfway	41	VI	1600
Harris	44	V	1665
High	42	VII	1640
Horsehead	43	VI	1640
Irving	41	VIII	1670
Island	42	VII	1590
Jag	42	VI	1625
Katinka	43	VI	1655
Little Arbor Vitae	40	VII	1605
Little St. Germaine	40	VIII	1610

TABLE 1. *Elevations of lakes in Vilas County, indicated in feet above sea level.*—(Continued)

Lake	Town No.	Range E.	Elevation
Lone Tree	41	VIII	1680
Long	41	VII	1650
Lost	40	VIII	1620
Lynx	43	VII	1700
Manitowish	42	V	1590
Mann	41	VII	1625
Muskellunge	41	VII	1635
Oswego	42	VII	1655
Oxbow	43	VII	1690
Papoose	43	VI	1640
Plum	41	VIII	1635
Plummer	40	VI	1625
Pokegama	41	V	1570
Presque Isle	43	VI	1635
Rest	42	V	1590
Rock	44	V	1640
Rock	41	VII	1630
Ross	40	VII	1637
Rozen	40	VII	1615
Sand	41	V	1615
Shishebogama	40	V	1565
Star	41	VIII	1670
Stearns	41	VI	1610
St. Germaine	40	VIII	1593
Sturgeon	42	V	1580
Sugarbush	41	V	1605
Trout	41	VII	1617
Twin	40	V	1595
White Birch	41	VIII	1665
Whitefish	40	V	1585
White Sand	42	VII	1636
Wishou	40	VI	1620
Wolf	43	VII	1640

BED ROCKS

Outcrops. Vilas County is nearly devoid of outcrops, only three are known in the region surveyed. Two ledges in secs. 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 detailed logs of the numerous drill holes. 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 these data were 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

[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. 18, pp. 65–130, 1915.

considerable amount of red clay probably derived from the red Keweenawan and Huronian rocks to the north. It is not at all probable from these 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 granits 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

Elevation. The highest known point in the area surveyed is the hill on which Muskellunge 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 Shishebogama Lake in T. 40, R. 5 E. at 1565 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 (fig. 2). 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 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 115 feet.[2]

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

Drift Deposits

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 (fig. 1). 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 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 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. 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. 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, es-

[3] Thwaites, F. T., The origin and significance of pitted outwash: Jour. Geology vol. 34, pp. 308–319, 1926.

pecially where bowlders are present. 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 (fig. 2). 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. The terminal moraines form elevations above the adjacent outwash areas. The material of the moraines consists of glacial till, ill-assorted gravel, 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 (fig. 1). Of these only the northernmost, the Winegar moraine, contains a large amount of till. This till is red in color and contains pockets of bowldery sand and red clay. 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 Muskellunge, are, so far as could be discovered, composed wholly of assorted material. They can be distinguished from the adjacent outwash by the great abundance of bowlders, 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 bowldery 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

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

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.

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 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 moraines. 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 bowldery, 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 Winegar 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. 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.

Glacial History

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 scat-

tered moranic 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.

Muskellunge Moraine. The halt of the ice margin which allowed the deposition of the Muskellunge 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 soon have succumbed to the sun's rays; but while the ice margin was at the Muskellunge Moraine, vast quantities of water flowed from the glacier and buried these 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 originally deposited the moraine rose above the outwash plain to the south in only a few places, notably at the hill where the Muskellunge 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. 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 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 Muskellunge 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. The result was to cut away a large portion of the high level plain south of the Muskellunge 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

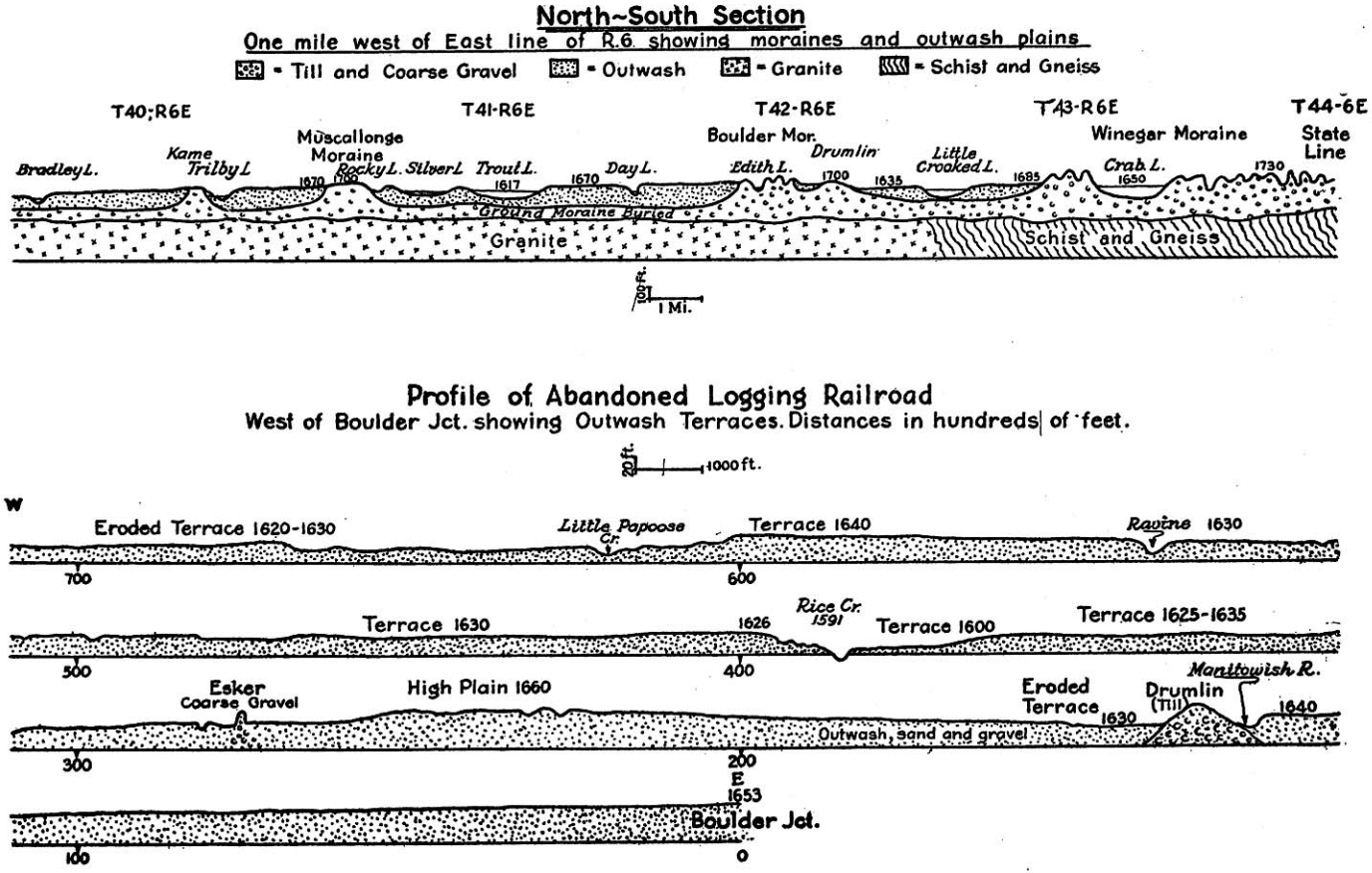
North-South Section
One mile west of East line of R.6 showing moraines and outwash plains
= Till and Coarse Gravel
= Outwash
= Granite
= Schist and Gneiss
T40;R6E
T41-R6E
T42-R6E
T43-R6E
T44-6E
Bradley L.
Kame
Trilby L
Muscallonge Moraine
Rocky L.
Silver L
Trout L.
Day L.
Boulder Mor.
Edith L.
Drumlin
Little Crooked L.
Winegar Moraine
Crab L.
State Line
1870
1660
1617
1670
1700
1635
1685
1650
1730
Ground Moraine buried
Granite
Schist and Gneiss
1 Mi.
Profile of Abandoned Logging Railroad
West of Boulder Jct. showing Outwash Terraces. Distances in hundreds of feet.
1000 ft.
W
Eroded Terrace 1620-1630
Little Papoose Cr.
Terrace 1640
Ravine 1630
700
600
Terrace 1630
1626
Rice Cr. 1591
Terrace 1600
Terrace 1625-1635
500
400
Esker
Coarse Gravel
High Plain 1660
Eroded Terrace 1630
Drumlin (Till)
Manitowish R.
1640
Outwash, sand and gravel
300
200
E
1653
Boulder Jct.
100
0

FIG. 2.

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. 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). 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 (fig. 2).

Postglacial. The glacial history of the area closes with the completion of the Winegar 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 excavation. 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. 40, 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. "W"
T. 41, R. 5 E. Sec. 30.	Outwash	—Roadside pit on new road to Powell
Sec. 34.	Outwash	—Largest pit in area, ¼ 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. 3.	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

Location	Origin	Remarks
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 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.

[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.

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.