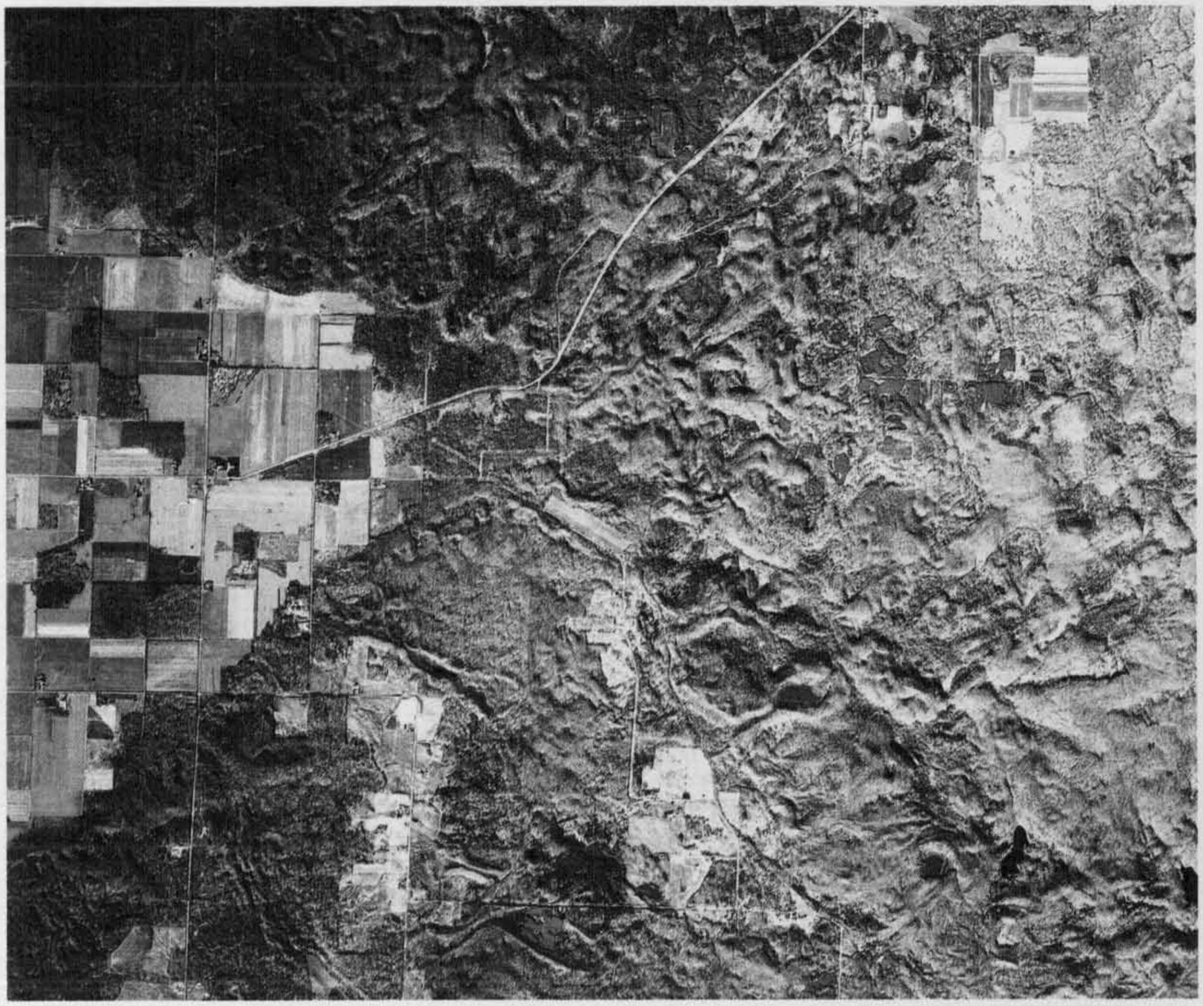
Glacial and Related Deposits of Langlade County, Wisconsin

D. M. Mickelson



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A description of the geologic materials underlying the surface soil and overlying the solid rock in Langlade County, Wisconsin

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CONTENTS

PLATE

FIGURES

TABLES

Glacial and Related Deposits of Langlade County, Wisconsin

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INTRODUCTION

Most deposits above solid rock in Langlade County are the direct or indirect result of glaciation. During the last period of geologic time, the Quaternary, glaciers advanced into the county numerous times. We now have evidence for three separate glacial events: one about 15,000 B.P. (Before Present), one sometime previous to 40,000 B.P., and another considerably earlier glacial advance. Areas covered by these advances are shown in figure 1. These advances were recognized by Weidman (1907), and subsequent work by Thwaites (1943), LaBerge and Meyers (1983), Stewart (1973; Stewart and Mickelson, 1976), Nelson (1973; Nelson and Mickelson, 1974, 1977), Mickelson (Mickelson, Nelson, and Stewart, 1974), and Mode (1976) in Langlade and adjacent counties has added details to the glacial chronology. This report, and the map of the glacial deposits of Langlade County (plate 1), are the first detailed description of deposits specifically in Langlade County.

Glacial environments are complex, and, typically, deposits that form around and under glaciers are variable and have a wide range of characteristics. These different depositional environments are important in determining the soil types that

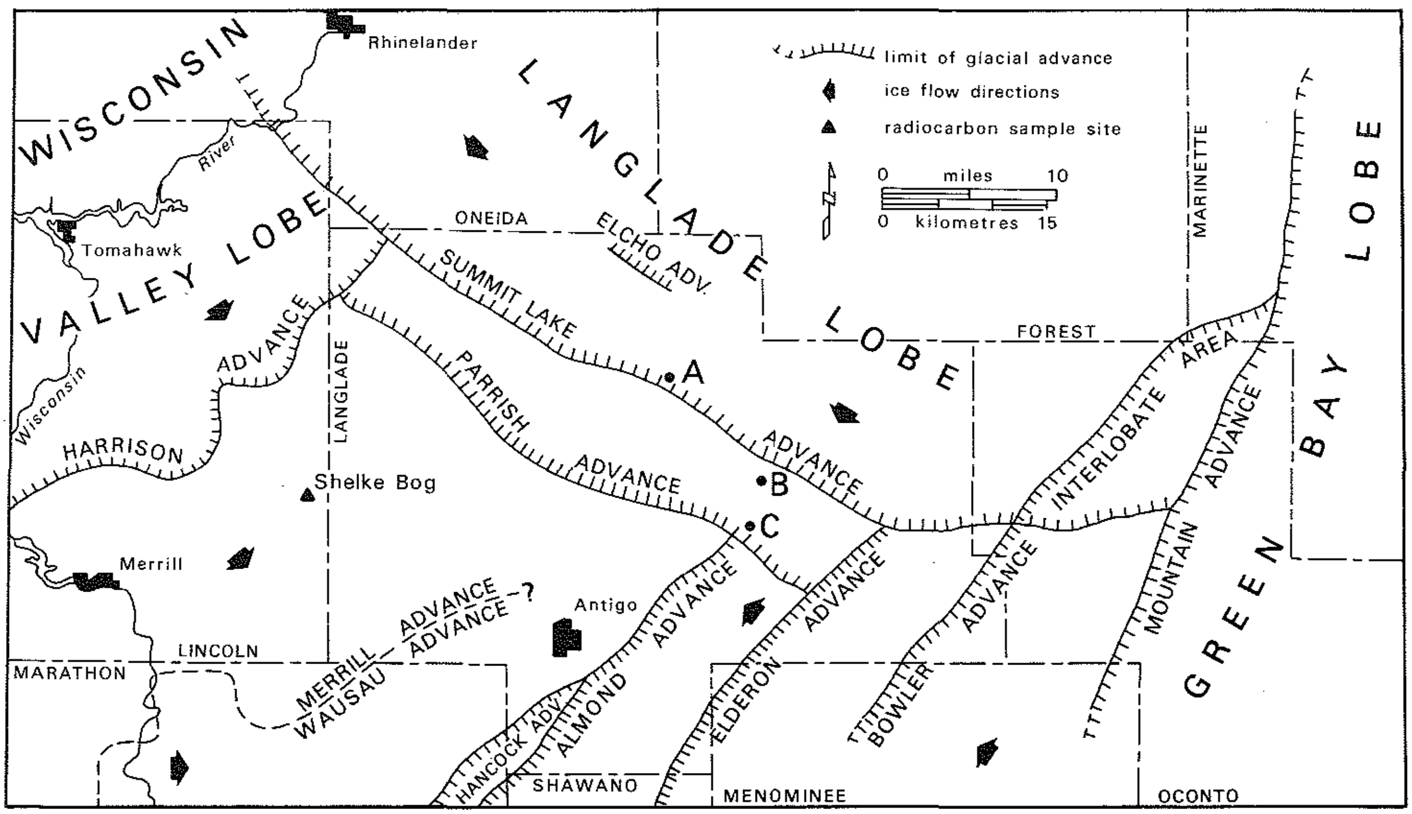


Figure 1. Map of north-central Wisconsin showing end moraine fronts and areas covered by various advances. Point A is location of buried Merrill till; points B and C are locations of Mapleview till under Nashville till.

have formed since deglaciation, roughness of the land, grain size of deposits, and, therefore, land-use suitability. Many of the scenic areas of the county are the direct result of glaciation as well.

The nature of glacial deposits also determines the hydraulic conductivity and percolation rate, both measures of how rapidly water moves through the ground. Thus, water supply, potential for groundwater pollution and interaction between surface water and groundwater are all better understood if a fairly detailed picture of the nature of glacier and stream deposits is available.

This report provides a brief description of Quaternary deposits in Langlade County. A map showing the distribution of deposits (plate 1) is included in an envelope at the back of this report. Although this report can be read and understood without reference to that map, I recommend that it be used if possible.

THE NATURE OF GLACIAL DEPOSITS

After glaciers have occupied an area for some time, they finally melt back, leaving a sequence of deposits that can be classified according to their grain size and other characteristics. During the erosion and transportation process glaciers tend to mix different sizes and produce sediment that is poorly sorted (well-graded). When this sediment is carried to the edge of the glacier and deposited directly by the ice, the sediment is called till (table 1). Thus, till is normally a poorly sorted sediment, typically containing clay-size to boulder-size material. Till carried as a debris-rich mat at the base of the glacier, called basal till, is typically very uniform and predictable. It is generally fairly compact and is commonly over-consolidated; that is, compacted by the weight of the ice. Normally most elongate grains have their long axis parallel to the direction of former ice flow and plunge, or tilt, upglacier. Some sediment transported by glaciers is not deposited at the base of the ice, however, but is carried up to the ice surface. Here there is opportunity for other processes to act.

If debris is relatively thin on the ice surface, landslides and mudflows commonly remold material and allow some sorting of grains. In this report, these variable materials are called supraglacial poorly sorted sediment (table 2). They are characterized by considerable variability in texture, some stratification or layering, and generally poor sorting. If the supraglacial debris cover is thick, no change in characteristics of the material occur and the material is called till. Although on some modern glaciers supraglacial till is thick enough that it is not reworked, it seems

Table 1. Material, topographic, and landform map units used in plate 1 and discussed in this paper. Names in each column are used in combinations as shown on plate 1.

Material	List of Modifiers	Landform
Sediment of the Late Wisconsin Glaciation		
		Terrace (t)
	Uncollapsed (u)	Fan (f)
Fluvial gravel (g)		Apron (a)
(predominates	Pitted (p)	Plain (p)
over sand)		Ice-walled lake plain (n)
		Lacustrine plain (l)
Fluvial and lacustrine	Hummocky (h)	Tunnel channel (n)
sand (s)		Complex (c)
(predominates		End moraine (e)
over gravel)		
Lacustrine silt and clay (c)		
Basal till and	Streamlined (s)	
till-like		
sediment (t)	Gently Rolling (r)	
Postglacial sediment		
Organic deposits		
Non-glacial stream deposits		

Landforms shown by line symbol: drumlin, esker, moraine ridge

Table 2. Lithostratigraphic units recognized in Langlade County. All formations and members are defined and formally named by Mickelson and others (1984). Letters in parentheses are those used on plate 1.

Formation	Member	Materials
Marathon	Wausau (W)	till and till-like sediment
Lincoln	Merrill (L)	till and till-like sediment gravel
Copper Falls	Nashville (N)	basal till and till-like sediment sand and gravel silt and clay
	Bass Lake (B)	basal till and till-like sediment gravel
Horicon	Mapleview (M)	basal till and till-like sediment sand and gravel silt and clay
Undifferentiated	Undifferentiated (U)	sand and gravel silt and clay

unlikely that this was the case in Langlade County. The distinction between supraglacial poorly sorted sediment and basal till is difficult except where exposure is good. Because of this and because till and supraglacial sediment are similar for land management purposes, a distinction between these is not made on plate 1.

Typically water is present in the near-glacial environment, and the sorting process can produce clean sand or sand and gravel. Finer grains (silt and clay) are carried to small lake basins on the ice or, perhaps, away from the ice. If mappable deposits of well sorted stratified (layered) sediment are present, even if they were deposited on the ice, they are mapped separately as sand or sand and gravel, not as supraglacial poorly sorted sediment.

Sediment carried by the glacier may not be deposited by the glacier or, if it is deposited, can be picked up in a stream and moved again. Water produced by melting of ice moves large amounts of sediment away from glaciers. All these sediments, whether deposited in contact with the ice or carried away from the ice and deposited by streams or in lakes, are characterized by having better sorting than till and more stratification. Coarse deposits are called gravel, finer ones sand, and still finer are silt and clay. The array of materials and landforms found in Langlade County and shown on plate 1 is shown in table 1.

Other depositional agents or environments recorded in the county date from late-glacial and postglacial time. As glaciers began to retreat, braided streams with many interwoven channels were present on the Antigo flats (the broad plain surrounding Antigo) and on flat or gently sloping surfaces elsewhere. These streams had great fluctuations in discharge because the amount of water being produced by the glaciers varied with temperature and the amount of sunshine. Silt was deposited on the surface of the floodplain during times of high water and dried out and was carried away by the wind. This silt was deposited locally as a mantle of silt over the landscape and is called "loess". The distribution of loess is not shown on plate 1, but its distribution is discussed later in this report. Deposits on floodplains of modern rivers and deposits of organic matter are shown on plate 1, but are not discussed in this report.

Not only do glacial deposits differ from one another because of depositional environment, but also because of the characteristics of the source rocks. In Langlade County, for example, till and sand and gravel derived from the east and southeast contain fairly abundant dolomite pebbles. Sediment derived from the north has much less dolomite but more metamorphosed basalt (greenstone). Similar differences in composition exist in other grain sizes and these are discussed later.

Because these compositional differences are fairly widespread, and because till of a given advance has a fairly uniform composition, differences in composition are used to separate lithostratigraphic units. Most units are separated primarily on the characteristics of the basal till of each advance, although some lithologic traits are carried into the associated sand and gravel. A more detailed discussion of stratigraphic units in the state is given by Mickelson and others (1984).

In Langlade County four main lithostratigraphic units are recognized, as shown in table 2 and figure 2. The oldest is the Wausau Member of the Marathon Formation. Nine samples of what was interpreted to be till from this unit average 50 percent sand, 32 percent silt, and 14 percent clay in the less-than-2-mm fraction. This till is pres-

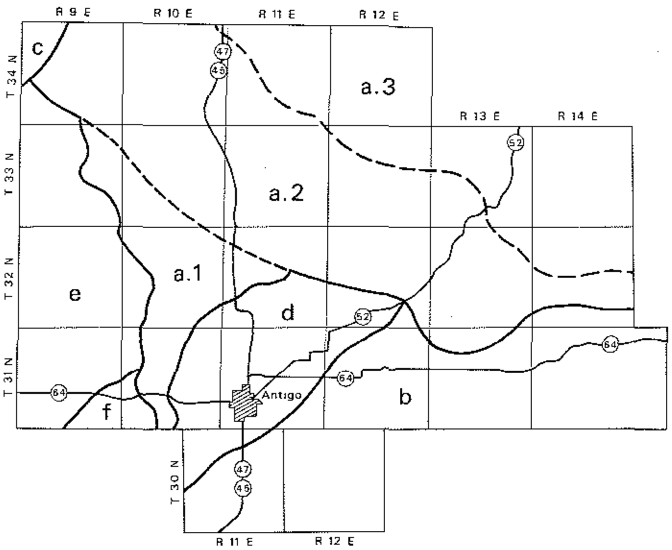


Figure 2. Physiographic areas of Langlade County discussed in text. Area covered by:

- a. Nashville Member of the Copper Falls Formation
- a.1 Outwash zone
- a.2 End moraine zone
- a.3 Drumlin zone
- b. Mapleview Member of the Horicon Formation
- c. Bass Lake till
- d. Undifferentiated outwash
- e. Merrill Member of the Lincoln Formation
- f. Wausau Member of the Marathon Formation

ent mostly in the southwestern part of the county in Ackley Township (T. 31 N., R. 9 E.), but it has been found beneath the younger Merrill Member of the Lincoln Formation near the west border of the county farther north (SW1/4SW1/4SE1/2 sec. 8, T. 32 N., R. 9 E). Exposures are sufficiently poor and weathering sufficiently great that different types of till and related deposits cannot be distinguished.

The next youngest stratigraphic unit is the Merrill Member of the Lincoln Formation. It contains till, supraglacial poorly-sorted sediment, and sand and gravel derived from the northwest. It is exposed at the surface in west-central Langlade County and is presumably present in the subsurface throughout the northern part of the county. Only one exposure of similar till is known north of the Parrish moraine (fig. 1), however. Samples of what was interpreted to be till of the member contain about 64 percent sand, 27 percent silt, 8 percent clay in the less-than-2-mm fraction and reddish-brown. Sand and gravel has variable texture depending on depositional environment.

Two more lithostratigraphic units containing till, one in the northern part of the county and one in the eastern part, are recognized (fig. 2). The Nashville Member of the Copper Falls Formation contains reddish brown gravelly, sandy till and associated sand and gravel and silt deposits. It is distinguishable from the otherwise similar Mapleview Member of the Horicon Formation that covers the eastern part of the county because it contains fewer dolomite and other sedimentary pebbles, fewer granite and more basalt pebbles, and fewer pink feldspar grains. This distinction, also recognized by Thwaites (1943) on the basis of Paleozoic dolomite content, occurs because the Mapleview Member of the Horicon Formation was deposited by ice and melt water of the Green Bay Lobe, ice that flowed into the county from the southeast. The Nashville Member was deposited during the advance and retreat of the Langlade Lobe, a sublobe of the Chippewa Lobe (fig. 1). This ice, derived from the northeast, did not cross Paleozoic sedimentary rocks, and thus contains only a few percent of these lithologies.

The other sand and gravel deposits in the county are those that cannot be put into one of the above formations. This unit contains much of the sand and gravel of the Antigo flats. Water from both lobes was responsible for deposition of this gravel and sand and, except on the east edge of the flats, these outwash deposits cannot be associated with either the Horicon or Copper Falls Formation.

PHYSIOGRAPHIC REGIONS OF THE COUNTY

Because the lithostratigraphic units discussed above are exposed at the surface in certain parts of the county, and because these areas have distinctly different landform characteristics, the surficial deposits of the county are best described by region (fig. 2).

Area Covered by the Wausau Member of the Marathon Formation

The Wausau-till area (fig. 2) is the most poorly known area of the county and it is also the area with the thinnest deposits (plate 1). There are no exposures and all information is derived from air-photo interpretation, auger holes, and extrapolation from adjacent Marathon County where some exposures have been described.

Samples collected in Langlade County and interpreted to be Wausau till contain an average of 52 percent sand, 34 percent silt, and 13 percent clay in the less-than-2-mm fraction (table 3). The samples collected show a great deal of variability (Mickelson, 1987) and it may be that some of what was interpreted to be till is actually poorly sorted material. The size distribution of the samples analyzed is shown in figure 3. Although not enough samples have been analyzed in this study to be significant, a summary of the clay mineralogy of the deposits in north-central Wisconsin was given by Stewart and Mickelson (1976) and is shown in figure 4. A summary of the magnetic susceptibility of samples is given in figure 5, and clay minerals determined in this study in figure 6. In some places, particularly beneath peat in Ackley Township, there are thin (2 to 4 m) clay or silty clay deposits above the till. Sand and gravel was encountered in only two auger holes in the Wausau till area, and it is covered by peat.

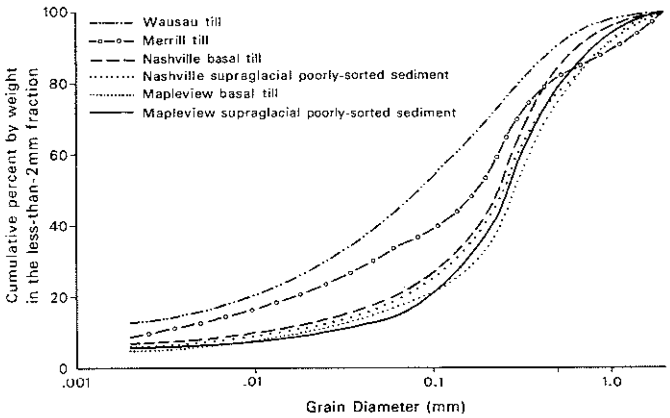


Figure 3. Mean cumulative percent of each size fraction in samples of each stratigraphic unit.

The till is thin (1-to-4 m) and overlies weathered Precambrian bedrock (plate 1, profile 31 N.). In sections 23, 24, and 26 of T. 31 N., R. 9 E. and sections 20, 29, and 30 of T. 31 N., R. 10 E. weathered granite was found under the till in auger holes. To the north and west of this, the deposits overlie weathered Precambrian metamorphic rock and probably some granitic rocks. A silt cap (loess) about 1 m thick covers the gently sloping upland surfaces on the area.

Weathered metamorphic rock provides a source of clay in Marathon County, and this rock has some potential as a clay resource. The deposits are thin, however, and most are below the water table. Except for localized clay deposits of glacial lakes in the northern part of the county, this is the only area with a significant amount of low-permeability sediment.

Because there is only one exposure of till of the Wausau Member in the county, most interpretation of age and genesis must be taken from work in Marathon County. This area was considered part of the Driftless Area (unglaciated) by Weidman (1907), but it is now clear that in Langlade and at least part of Marathon County some glacial deposits do exist on the land surface. Stewart studied weathering profiles in the Wausau deposits (Stewart and Mickelson, 1976) and found that the deposits are deeply weathered, suggesting they were deposited during an early, pre-Wisconsin glaciation. It can be seen in figure 4 that the Wausau samples contain considerably less illite and kaolinite plus cholorite than other units in the area. Mickelson and Stewart (1976) argue that this is because of weathering of the primary minerals, illite and chlorite, and the development of vermiculite and montmorillonite.

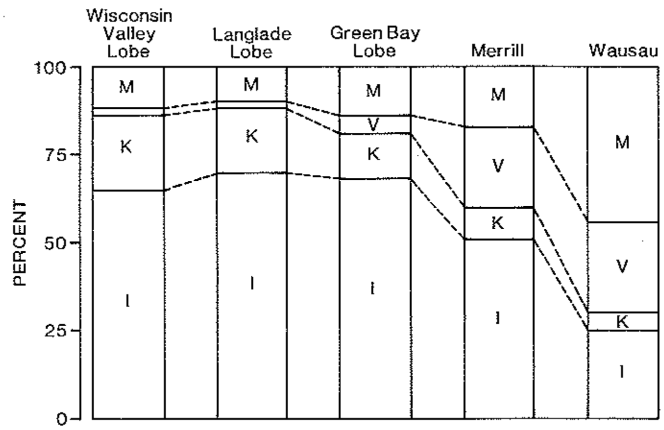


Figure 4. Clay-mineral composition of samples collected from till and till-like material in north-central Wisconsin (from Stewart and Mickelson, 1976). Montmorillonite (M), vermiculite (V), kaolinite and chlorite (K), and illite (I).

Stewart (1973) measured the fabric (orientation of elongate pebbles) in the till in two places and found that ice depositing the till flowed from west to east. LaBerge and Meyers (1983) also suggest

Table 3. Mean grain size and magnetic susceptibility and their standard deviations of samples interpreted to belong to various types in Langlade County. Numbers of samples are shown in brackets.

	Sand (2-0.0625 mm)	Silt (0.0625-0.002 mm)	Clay (less than 0.002 mm)	Magnetic Susceptibility
Wausau till [9]	52.1 (12.4)	34.4 (13.2)	13.4 (4.3)	5.9 (1.7[a])
Merrill till [12]	63.1 (9.1)	27.1 (9.1)	9.7 (7.5)	9.5 (3.4)
Nashville basal till [48][b]	77.2 (2.9)	16.1 (2.8)	6.7 (2.0)	7.3 (0.9)
Nashville supraglacial [32] poorly sorted sediment	78.6 (3.4)	15.9 (2.7)	5.3 (2.0)	8.0 (1.1)
Mapleview basal till [20][c]	81.9 (5.7)	13.2 (4.9)	4.7 (2.1)	6.3 (2.3)
Mapleview supraglacial [16][d] poorly sorted sediment	84.4 (3.6)	10.1 (3.6)	5.5 (1.5)	6.0 (1.9)

[a]Calculation omits samples 26-82 and 62-82.
[b]42 samples for magnetic susceptibility
[c]9 samples for magnetic susceptibility
[d]12 samples for magnetic susceptibility

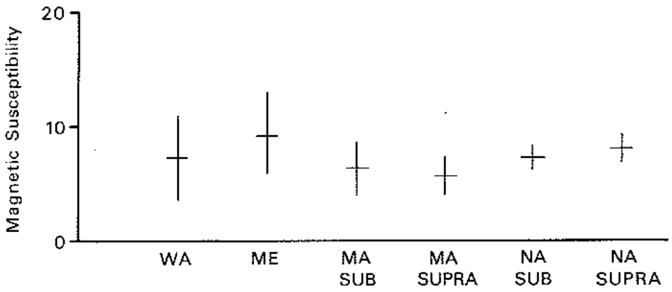


Figure 5. Plot of mean and standard deviation of magnetic susceptibility in arbitrary units of samples of each stratigraphic unit or facies. Stratigraphic units: Wausau till (WA), Merrill till (ME), Mapleview basal (MA SUB), Mapleview supraglacial (MA SUPRA), Nashville basal (NA SUB), Nashville supraglacial (NA SUPRA).

this flow direction based on the distribution of boulders in the till and their relationship to Precambrian bedrock outcrops.

There is good evidence that a period of weathering took place between the deposition of the Wausau Member and deposition of the overlying Merrill Member. At one place in Langlade County (low roadcut at SW1/4SW1/4SE1/4 sec. 8, T. 33 N., R. 9 E.) a buried soil is developed in Wausau Member deposits and covered by deposits of the Merrill Member. This weathering profile may be age equivalent to the Sangamon Paleosol of Illinois and southern Wisconsin (Schneider and Follmer, 1983) as suggested by Stewart, but there is no conclusive evidence of age.

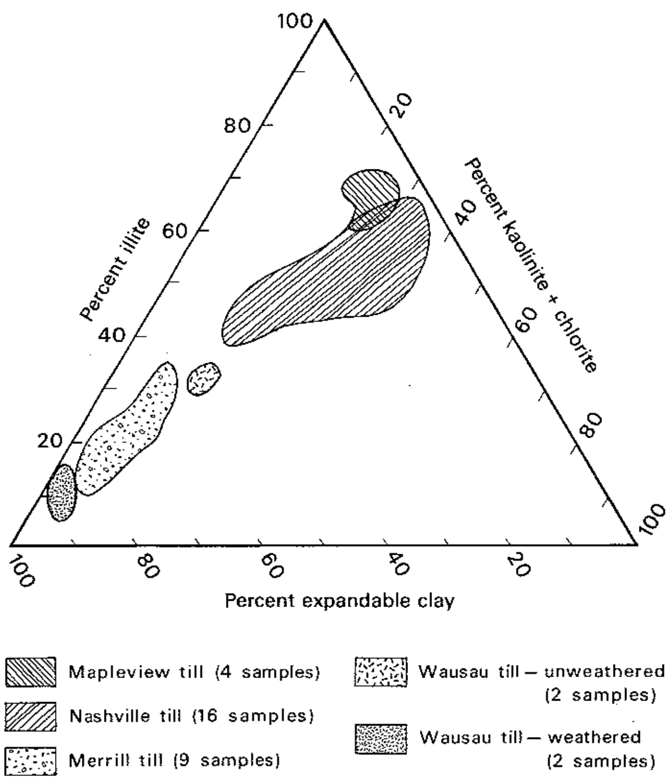


Figure 6. Triangular diagram showing semi-quantitative determination of clay-mineral content. Sample points represent individual samples.

Area Covered by the Merrill Member of the Lincoln Formation

West and north of the Wausau till area the landscape has more relief and is better drained. In general, Precambrian bedrock is deeper below the surface, more sand and gravel is present, and till is sandier. Three sediment types in the Merrill Member were recognized, and analytical results from samples were grouped accordingly.

Uniform basal till exists over much (probably 80 percent) of the rolling-hill landscape of western Langlade County. It is reddish brown, gravelly sandy loam and the less-than-2-mm fraction of samples analyzed contains about 63 percent sand, 27 percent silt, and 10 percent clay (table 3). A diagram showing distribution of grain sizes of samples is shown in figure 3. The average magnetic susceptibility of samples analyzed is 9.5, somewhat larger than other tills in the county. No carbonate was present in six samples tested, but it may have been removed by post-depositional leaching.

Only three samples that in the field appeared not to be uniform basal till were collected. Analysis of these samples for grain size and magnetic susceptibility indicates no significant difference between them and the other Merrill till samples. These data are not included in summary statistics for the Merrill till, however.

Stratified and sorted deposits included in this member are variable in grain size. For the most part, sand or gravelly sand (plate 1) is present in valleys surrounded by the till surfaces. A few scattered gravel deposits (plate 1) are present as higher river terraces or kame terraces.

Most glacial landforms in the Merrill till area have been destroyed by post-glacial erosion. Deposits are thin over Precambrian bedrock in the hills, and the landscape shows the grain of the underlying rock. Thickness of Quaternary deposits ranges from only a few metres to about 15 m over buried valleys (plate 1, profiles). One small ridge that may indicate a former ice margin position has a northeast-southwest trend through sec. 19, T. 32 N., R. 10 E., and secs. 24 and 25, T. 32 N., R. 9 E. The Vilas lookout tower is on a high part of this ridge. Although the ridge may be mostly bedrock, it does contain partially washed till-like deposits and coarse sand and gravel that appears to have been deposited in an ice-marginal position. Another similar ridge of ice-marginal deposits occurs in NE1/4 sec. 6, T. 31 N., R. 9 E. and extends to the north through secs. 31, 32 and 29 and 20, T. 32 N., R. 9 E. A local concentration of what appears to be lake sediment (fine sand and silt) appears on the south-facing slope in the NE1/4 sec. 31, T. 32 N., R. 10 E. The area is small, however, and the deposits are not shown on the map (plate 1).

Most of the Merrill till area is blanketed with 0.3 to 1 m of windblown silt. Steeper slopes and lower alluvial surfaces do not have this cover.

The fabric of the Merrill till has not been measured in Langlade County. However, measurements by Stewart (1973) and Stewart and Mickelson (1976) indicate that ice flow toward the southeast deposited the till. The orientation of the ice-marginal ridges described above indicates a similar ice-flow direction, as does the orientation of the southern and eastern margin of the Merrill Member (fig. 2). The contact with the Wausau Member to the south, although hard to map precisely, is evidently the maximum position of the advance of the glacier that deposited the Merrill till. Farther north, the Merrill till is under sand of the Copper Falls Formation. Although one drill hole in sec. 9, T. 32 N., R. 10 E. penetrated to Merrill till, a few other drill holes through the outwash did not. The easternmost location where possible Merrill till has been found is beneath the Nashville Member to the north, about 5 km west of Pearson in NE1/4 sec. 2, T. 33 N., R. 11 E. (fig. 1, point A). It is not known how much farther east the Merrill Member extends in the subsurface.

Few radiocarbon dates exist to establish the age of the Merrill Member. A peat deposit on top of Merrill till and beneath sand of the Nashville Member occurs on Schelke Road, 1.6 km west of the Langlade County line in Lincoln County, in the NE1/4NE1/4NE1/4 sec. 26, T. 32 N., R. 8 E. (Schleke bog, fig. 1). Radiocarbon dates of greater than 36,500 (ISGS-262) and 40,800 ± 2000 B.P. (ISGS-256) of the peat indicate that the till below is older than 40,000 years and that the area was ice free by 40,000 years ago (Stewart and Mickelson, 1976; Dirlam, 1977). Clay minerals in the till show a pronounced change in weathering with depth, unlike till of the younger Nashville and Mapleview Members (fig. 7). Weathering of the clay (fig. 4) is not, however, as intense as in the Wausau or Edgar Members of the Marathon Formation (Stewart and Mickelson, 1976, Mode, 1976). The Merrill Member, therefore, is most likely of Early Wisconsin age, and was deposited sometime between 40,000 and 80,000 years ago.

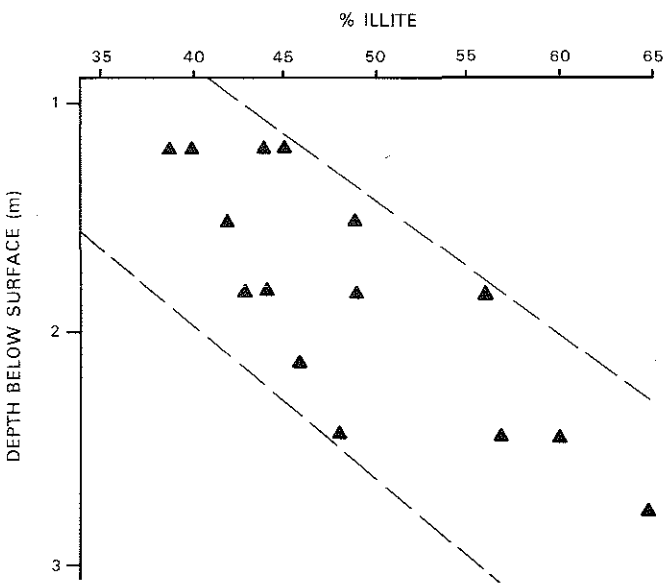


Figure 7. Plot of illite percentage against depth for samples of the Merrill till. (From Stewart and Mickelson, 1976).

Area Covered by the Nashville Member of the Copper Falls Formation

The whole northern part of Langlade County is covered with deposits of the Copper Falls Formation and younger stream and organic deposits. Glacial deposits at or near the surface in this area are of Late Wisconsinan age, or between 22,000 and 12,000 years old. Glaciers entered the northwest corner of the county from the northwest (Wisconsin Valley Lobe, fig. 1) and deposited the Bass Lake till (informal name, Nelson, 1973), and meltwater in, under, and in front of the ice deposited associated sorted sediment. The rest of northern Langlade County is blanketed with deposits of the Nashville Member of the Copper Falls Formation (fig. 2). This member consists of till deposited by ice of the Langlade Lobe as it flowed into the county from the northeast and associated meltwater deposits. Because the ice advance took place fairly recently, glacial landforms dominate the landscape. Some bedrock relief exists (for example, the Wolf River Valley in the central part of the region and streamlined hills in the northeast corner of the county), but it is not as obvious as in the Merrill or Wausau till areas. Part of this area was described and mapped by Thwaites (1943). Subsequent interpretation of glacial history is given in Nelson (1973), Mickelson, Nelson and Stewart (1974), and Nelson and Mickelson (1977).

Materials Contained in the Nashville Member

Better exposures, better preservation of deposits, and a larger area of distribution make it possible to recognize more types of sediment in this unit than either the Merrill or Wausau Members. The till of the Nashville Member was described and informally named the Nashville till by Simpkins (1979). The term is used to designate the reddish brown, gravelly loamy sand and sandy loam till and associated deposits left by the Langlade Lobe. The till-like deposits can be separated into two groups: uniform basal till, and less uniform supraglacial deposits that may have been created by mudflow or other mass wasting, direct melting out from stagnant ice, or even some transport by water (fig. 8). Some of these supraglacial deposits were probably transported above the base of the glacier instead of at the base but this distinction cannot be made. It seems likely, however, that most of these deposits were on top of a significant thickness of ice for some time, and they are here called the supraglacial poorly sorted sediment. In many cases this material was also moved by post-glacial slope processes. Presumably what is called basal till was carried as a very debris-rich layer at the base of the glacier and, although some movement between individual grains may have taken place during meltout of interstitial ice, the till retains the

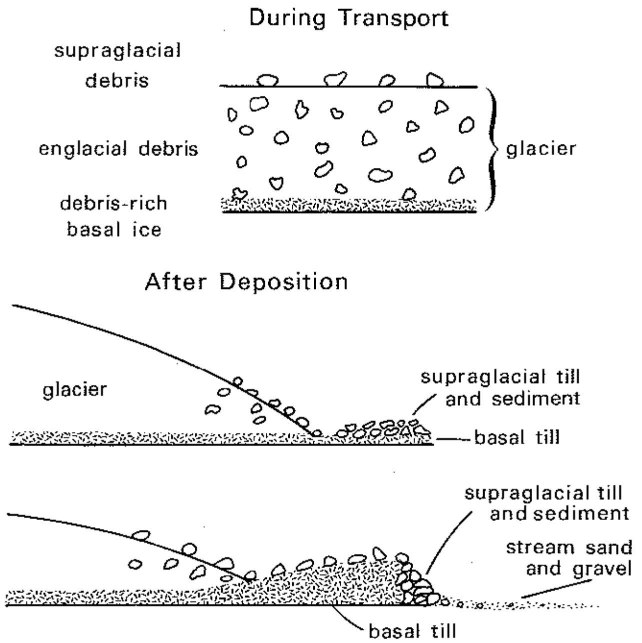


Figure 8. Sketch of depositional environments of deposits described in this report.

characteristics of basal transport (fig. 8). Although melt out at the surface of a debris-rich layer of ice probably is responsible for some of the uniform till, a distinction between this and lodgement or subglacial melt-out till cannot be made.

As in the Mapleview Member in the southeastern part of the county, what is here interpreted as basal till has very uniform texture. The 53 samples of Nashville basal till on which grain size was measured contain about 77 percent sand, 16 percent silt, and 7 percent clay in the less-than-2-mm fraction. The 31 samples of what is interpreted to be supraglacial poorly sorted sediment average about 79 percent sand, 16 percent silt, and 5 percent clay. It can be seen from figure 3c and d that although the mean grain size is about the same, slightly more variation exists in the supraglacial poorly sorted sediment, especially in the coarser sand fractions.

Samples from two deep drill holes (figs. 9, 10) show how uniform the basal till is in vertical section. Although these two holes were drilled several kilometres apart and show between 4 and 5 percent difference in mean sand content of basal till between holes, sand content in each hole is remarkably uniform. Only near the surface do samples show much variability, and this material is interpreted as supraglacial sediment in the hole shown in figure 10. Magnetic susceptibility is also very uniform throughout the vertical sequence.

At three sites where good exposures are available, detailed studies were done to distinguish the basal, and supraglacial types of the Nashville Member and to try to understand their genesis. Figures 11, 12, and 13 show detailed descriptions of these sites and diagrams showing the orientation of long axes of elongate pebbles. Till fabric measurements in basal till show a uniformly northeast plunge of the axes as would be expected if there had been no reorientation of grains after the fabric was developed. Fabric measured in the supraglacial poorly sorted sediment was not uniformly parallel to ice flow direction, but instead parallel to the present land surface or to weakly developed stratification in the material. This is the case at the County J site (fig. 11) where lenses of obviously flowed material have pebbles with long axes parallel to slope (west), but basal-till fabric below is oriented to the northeast.

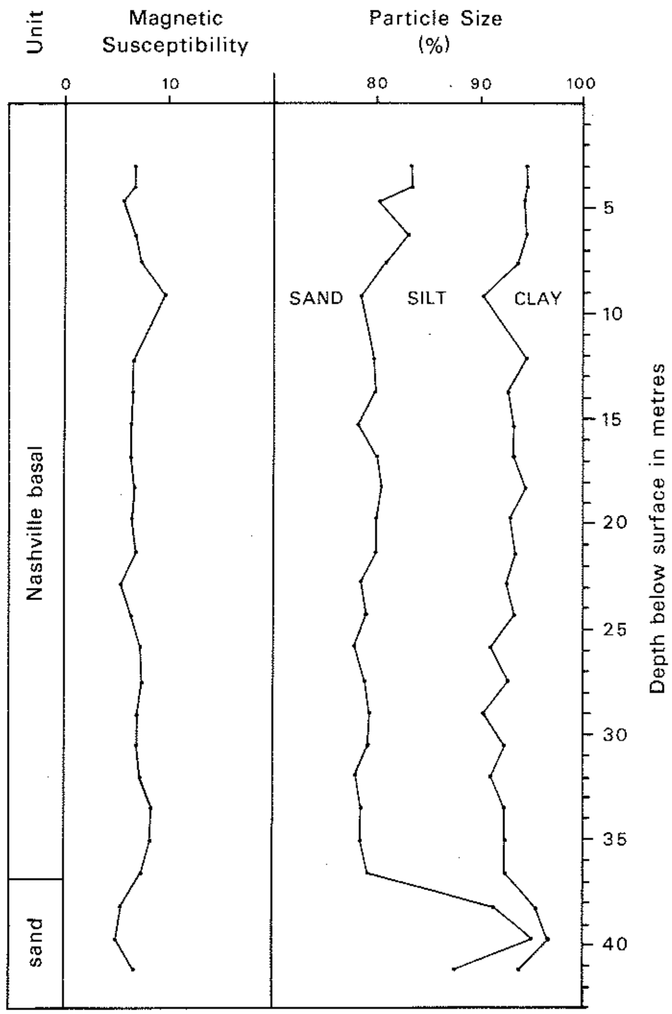


Figure 9. Plot of depth against magnetic susceptibility in arbitrary units and percent of sand, silt, and clay in the less-than-2-mm fraction from drill hole on Highway S, SE¼ NE¼ SE¼ sec. 8, T. 32 N. R. 12 E.

What is called supraglacial poorly-sorted sediment in this paper is generally recognized by its variability in grain size and sorting and there is often a weakly developed stratification. The variability of the supraglacial sediment is especially well shown in figures 10 and 12. About 5 m of supraglacial sediment is exposed in a small borrow pit (Bogus pit) and shows weakly developed stratification dipping toward the southwest. The

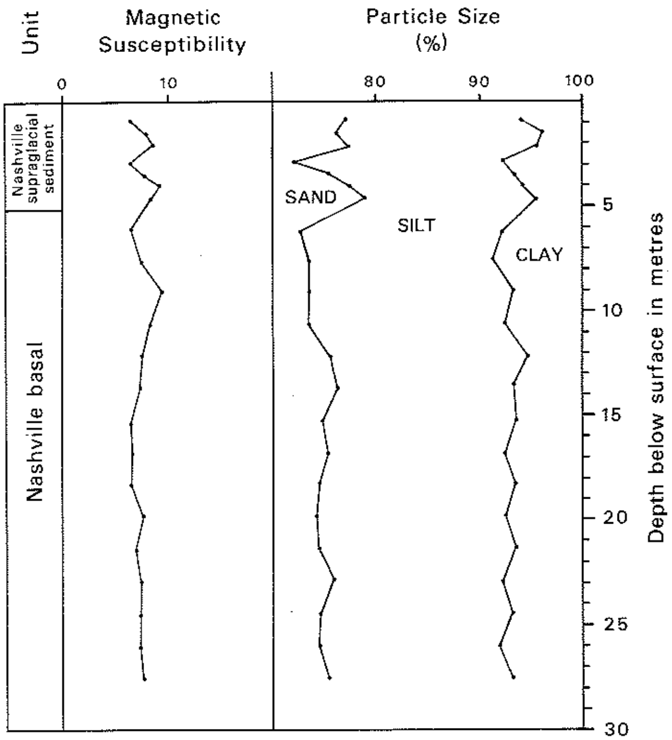


Figure 10. Plot of depth against magnetic susceptibility in arbitrary units and percent of sand, silt, and clay in the less-than-2-mm fraction from drill hole at Bogus pit, NE¼NE¼NW¼ sec. 27, T. 33 N., R. 10 E.

fabric parallels this southeast dip (fig. 12). As noted in figures 11, 12, and 13, clasts in the till commonly have clean sand layers that are 1 or 2 grains thick around them. Although these are present in some of the till interpreted to be basal in Langlade County, they are not as common or as thick as in the supraglacial sediment. Perhaps some of the sediment called supraglacial poorly sorted sediment was transported on hill slopes after deglaciation; however, it seems unlikely in most cases that on steep hill slopes much accumulation would have taken place. Thick hill-slope sediment does occur in places at the base of slopes.

Although in southern Wisconsin what is interpreted to be basal till and supraglacial till is mineralogically distinct (Johnson and others, 1982), no such difference is apparent here. It is possible that more samples or more detailed petrologic study would identify differences, but none have been found in Vilas County either (Attig, personal communication, 1984).

Samples of basal till and supraglacial sediment in which clay mineral compositon was measured contain more illite and probably chlorite than tills of either the Merrill or Wausau Members of the Marathon Formation. A small amount of carbonate is present in the basal till, but it is leached to depths greater than 3 m in most places. Even in unweathered sections there is considerably less carbonate than in the Mapleview Member (table 4) of the Horicon Formation. Of the pebbles (10 to 50 mm) counted from the unleached Nashville Member, (tables 5, 6) 2 to 6 percent of the pebbles are dolomite. In contrast, about 25 percent of the pebbles counted from the Mapleview Member are dolomite (table 4). Thwaites (1943) reported similar compositions of the deposits in these lobes. This is the easiest way to distinguish the two formations in Langlade County if the samples are not leached. The percentage of sedimentary pebbles (table 7, fig. 14) also shows the same thing. Supraglacial sediment is thin enough that it is leached in most places and carbonate data for this facies are probably meaningless. At least some carbonate clasts in the Nashville Member are Paleozoic age and were probably derived from carbonate-rich gravel of the Green Bay Lobe that is known to exist below Nashville till in the Crandon area (Simpkins, 1979).

Magnetic susceptibility of samples of basal and supraglacial poorly sorted sediment that were analyzed is not significantly different from each other, nor are they significantly different from other stratigraphic units in the county (fig. 5). Very coarse sand grains were examined under a binocular microscope. Counts of these (table 8) demonstrate that the Mapleview Member of the Horicon Formation in Langlade County has considerably more pink feldspar than Nashville Member sediment. This characteristic is particularly useful in distinguishing sand deposits where no pebbles are available. The ratios between the percentage of granite and basalt pebbles of samples of Nashville and Mapleview Members are also significantly different (fig. 15).

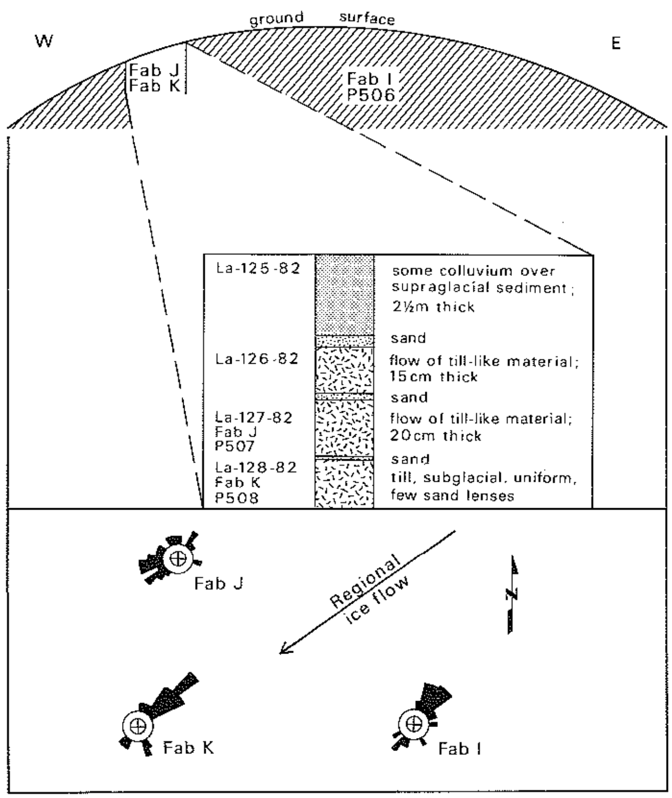


Figure 11. Description of County J site and rose diagrams showing the orientation of the long axes of pebbles in till and sediment flows.

Table 4. Percentage of pebbles in each lithologic category of samples collected from several facies of the Horicon Formation, Mapleview Member.

					UNLEACHED SAMPLES										LEACHED SAMPLES		
MATERIAL	BT	BT	BT	BT	BT	T	SS		S&G	S&G	S&G		S&G	S&G	SS	T	
LOBE	GB	GB	GB	GB	GB	GB	GB		GB	GB	GB		GB	GB	GB	GB	
DEPTH (m)	5.5	1.2	6	2	4.8	3	3		6	8	6		5	3	3	1.2	
SAMPLE	P510	P8	P10	P11	P17	P16	P7	MEAN	P21	P15	P201	MEAN	P202	P203	P511	P14	MEAN
GRANITE, PINK	15	16	22	19	35	23	29	22.71	6	25	28	19.67	28	11	16	31	21.50
OTHER GRANITE	24	4	10	6	10	13	12	11.29	10	15	21	15.33	21	18	66	16	30.25
GABBROIC IGN.	7	1	0	1	1	1	0	1.57	0	2	25	9.00	23	17	3	0	10.75
BASALTIC IGN.	2	5	7	5	11	12	4	6.57	13	8	9	10.00	3	1	1	15	5.00
DIORITIC IGN.	2	5	0	4	4	3	4	3.14	5	5	3	4.33	0	2	1	3	1.50
RHYOLITE PORPHORY	0	1	1	2	4	2	1	1.57	5	3	0	2.67	1	2	0	0	0.75
TOTAL IGNEOUS	50	32	40	37	65	54	50	46.86	39	58	86	61.00	76	51	87	65	69.75
RED QUARTZITE	0	8	7	3	1	3	4	3.71	1	3	1	1.67	1	1	5	6	3.25
OTHER QUARTZITE	4	4	9	6	5	7	6	5.86	4	7	2	4.33	4	5	1	10	5.00
GNEISS	0	9	3	2	2	2	2	2.86	6	3	1	3.33	4	1	0	4	2.25
IRON FORMATION	0	0	1	0	0	0	0	0.14	0	0	0	0.00	0	0	0	0	0.00
SCHIST	0	0	0	0	0	0	0	0.00	0	0	0	0.00	0	0	0	0	0.00
SLATE	0	0	0	0	0	0	0	0.00	0	0	0	0.00	0	0	0	0	0.00
OTHER METAMORPHIC	17	13	9	12	9	9	12	11.57	7	7	0	4.67	1	2	0	8	2.75
TOTAL METAMORPHIC	21	34	29	23	17	21	24	24.14	18	20	4	14.00	10	9	6	28	13.25
DOLOMITE, CHERT	24	37	25	25	13	23	22	24.14	35	18	8	20.33	2	2	1	0	1.25
BROWN SANDSTONE	0	3	2	10	2	1	2	2.86	4	1	2	2.33	7	4	0	3	3.50
RED SANDSTONE	2	1	0	3	1	0	0	1.00	2	0	0	0.67	3	2	0	1	1.50
OTHER SANDSTONE	5	0	0	0	0	0	0	0.71	0	0	0	0.00	2	9	7	0	4.50
SHALE	0	0	0	0	0	0	0	0.00	0	0	0	0.00	0	0	0	0	0.00
TOTAL SEDIMENTARY	31	41	27	38	16	24	24	28.71	41	19	10	23.33	14	17	8	4	10.75
VEIN QUARTZ	0	2	4	2	2	1	2	1.86	2	3	0	1.67	0	0	0	3	0.75

BT=Basal till, SS=Supraglacial sediment, T=Till, S&G=Sand and gravel

Table 5. Percentage of pebbles in each lithologic category of samples collected from several facies of the Nashville Member of the Copper Falls Formation.

	UNLEACHED SAMPLES							LEACHED SAMPLES						
MATERIAL	SS	SS	SS		S&G	S&G		S&G	S&G	BT	BT	BT	SS	
LOBE	LA	LA	LA		LA	LA		LA	LA	LA	LA	LA	LA	
DEPTH (m)	2.5	3	3		4	6		2	2.5	2.5	.8	1	2	
SAMPLE	P501	P12	P507	MEAN	P1	P2	MEAN	P3	P6	P4	P9	P18	P504	MEAN
GRANITE, PINK	19	24	7	13.16	24	16	15.09	8	34	5	38	9	8	17.02
OTHER GRANITE	7	12	4	11.48	16	12	11.48	18	15	15	16	16	12	14.30
GABBROIC IGN.	12	1	15	3.98	1	1	4.17	0	1	3	2	1	9	2.61
BASALTIC IGN.	2	12	1	11.55	2	0	9.16	1	4	7	5	14	5	5.87
DIORITIC IGN.	7	2	0	5.09	8	7	6.21	11	8	7	7	6	1	6.63
RHYOLITE PORPHORY	0	3	4	3.42	2	4	3.30	3	2	1	1	6	6	3.17
TOTAL IGNEOUS	47	54	31	48.68	53	40	49.42	41	64	38	69	52	41	49.61
RED QUARTZITE	0	5	4	2.97	4	8	3.36	9	5	9	3	3	4	5.13
OTHER QUARTZITE	0	9	11	7.52	10	17	8.42	7	7	9	3	8	16	9.29
GNEISS	29	9	3	7.64	4	9	7.86	6	2	5	4	11	4	6.05
IRON FORMATION	0	0	0	0.30	1	0	0.25	6	1	8	0	0	0	1.65
SCHIST	0	0	14	1.73	0	0	1.87	0	0	0	0	0	10	1.36
SLATE	0	0	0	0.98	1	0	0.38	0	1	0	0	1	0	0.44
OTHER METAMORPHIC	8	16	26	19.37	8	14	15.55	22	16	24	15	20	12	16.59
TOTAL METAMORPHIC	37	39	58	40.50	28	48	37.70	50	32	55	25	43	46	40.52
DOLOMITE, CHERT	3	1	5	2.14	8	4	3.06	0	0	0	0	0	1	1.82
BROWN SANDSTONE	14	2	1	2.90	3	0	3.38	3	2	1	4	1	8	2.83
RED SANDSTONE	0	0	1	1.61	1	3	1.94	0	0	0	0	0	1	0.85
OTHER SANDSTONE	0	0	0	0.36	0	0	0.13	0	0	0	0	0	1	0.15
SHALE	0	0	3	0.63	0	0	0.55	0	0	0	0	0	1	0.22
TOTAL SEDIMENTARY	17	3	10	7.64	12	7	9.06	3	2	1	4	1	12	5.87
VEIN QUARTZ	0	4	0	2.83	5	5	3.39	6	2	4	4	4	0	3.62

T=Till, BT=Basal till,SS=Supraglacial sediment, S&G=Sand and gravel

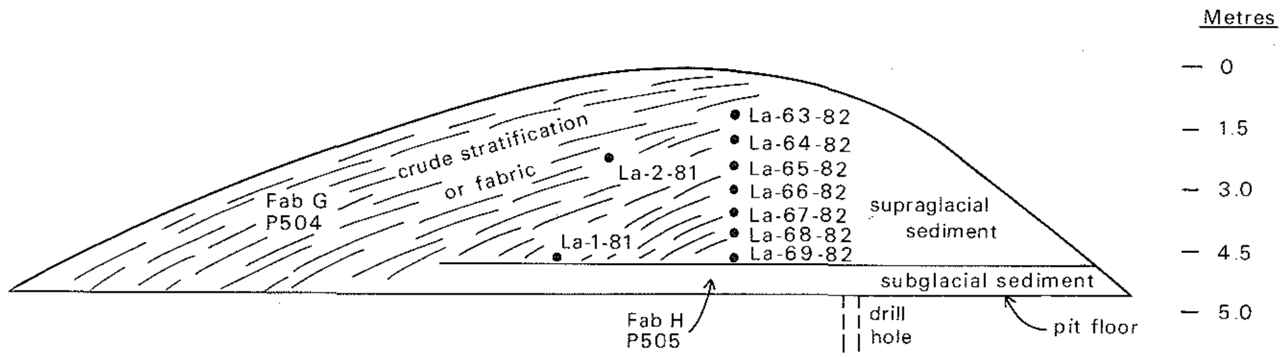
Table 6. Percentage of pebbles in each lithologic category of samples collected from till of the Nashville Member of the Copper Falls Formation.

	UNLEACHED SAMPLES												
MATERIAL	BT	BT	BT	BT	BT	BT	BT	BT	BT	BT	T	T	
LOBE	LA	LA	LA	LA	LA	LA	LA	LA	LA	LA	LA	LA	
DEPTH (m)	2	2	3.5	6	3.5	10	3.5	3	4.8	2	1.1	3	
SAMPLE	P502	P503	P505	P506	P508	P509	P5	P20	P22	P23	P24	P25	MEAN
GRANITE, PINK	14	6	14	5	6	4	11	23	9	8	24	5	10.75
OTHER GRANITE	11	9	4	3	4	5	10	19	17	15	15	12	10.33
GABBROIC IGN.	13	9	10	5	9	5	1	0	2	2	1	0	4.75
BASALTIC IGN.	6	6	5	2	0	0	10	16	23	19	17	17	10.08
DIORITIC IGN.	1	4	0	0	0	0	3	3	8	9	10	10	4.00
RHYOLITE PORPHORY	0	8	0	2	6	4	1	4	5	6	0	7	3.58
TOTAL IGNEOUS	45	42	33	17	25	18	36	65	64	59	67	51	43.50
RED QUARTZITE	0	2	5	2	2	2	7	4	1	1	3	3	2.67
OTHER QUARTZITE	4	8	12	13	13	13	8	5	7	7	7	7	8.67
GNEISS	8	12	0	9	6	11	3	6	6	5	3	3	6.00
IRON FORMATION	0	0	0	0	0	0	2	0	0	0	1	0	0.25
SCHIST	7	0	7	11	9	2	0	0	0	0	0	0	3.00
SLATE	0	0	0	0	0	0	8	0	1	0	0	1	0.83
OTHER METAMORPHIC	14	24	40	36	36	38	33	13	15	15	8	17	24.08
TOTAL METAMORPHIC	33	46	64	71	66	66	61	28	30	28	22	31	45.50
DOLOMITE, CHERT	1	6	0	5	6	5	0	2	0	0	1	4	2.50
BROWN SANDSTONE	10	0	0	0	0	1	1	2	0	1	1	7	1.92
RED SANDSTONE	0	2	2	0	2	2	0	0	2	6	4	1	1.75
OTHER SANDSTONE	1	2	0	3	2	3	0	0	0	0	0	0	0.92
SHALE	10	4	0	3	4	2	0	0	0	0	0	0	1.92
TOTAL SEDIMENTARY	22	14	2	11	14	13	1	4	2	7	6	12	9.00
VEIN QUARTZ	0	0	0	0	0	0	3	3	4	6	3	6	2.08

BT=Basal till, SS=Supraglacial sediment,T=Till, S&G=Sand and gravel

Table 7. Percentage of igneous, metamorphic, and sedimentary pebbles counted in samples of several types of sediment in Langlade County.

NUMBER	LOBE	MATERIAL	DEPTH	% IGNEOUS	% METAMORPHIC	% SEDIMENTARY	WEATHERED
P53	GB	S&G	3	54	20	26	N
P55	GB	S&G	11	55	28	17	N
P58	GB	S&G	6	52	18	30	N
P65	GB	S&G	4.5	51	27	21	N
P66.5	GB	S&G	4.5	47	39	14	N
P67	GB	S&G	3.5	53	36	11	N
P70	GB	S&G	2	52	35	13	N
P72	GB	S&G	4	47	16	36	N
P76	GB	S&G	4	51	15	34	N
P94	GB	S&G	3	53	27	21	N
P95	GB	S&G	3.7	51	21	28	N
P96	GB	S&G	6	51	23	27	N
P102	GB	S&G	8	51	11	38	N
GREEN BAY LOBE SAND AND GRAVEL				51.38	24.31	24.31	
P51	GB	T	6	50	17	33	N
P63	GB	T	2	60	35	14	N
P69	GB	T	3	49	41	10	N
P79	GB	T	6	51	7	37	N
P80	GB	T	4.5	53	8	39	N
P81	GB	T	4.5	43	4	53	N
P61	GB	SS	2	53	23	24	N
P78	GB	SS	6	52	9	43	N
P75	GB	T	6	53	26	21	N
GREEN BAY LOBE TILL AND SUPRAGLACIAL SEDIMENT				51.38	18.00	31.63	
TOTAL GREEN BAY LOBE SEDIMENT				51.38	21.15	27.97	
P57	GB	S&G	2	71	28	1	Y
P66	GB	S&G	1	46	51	3	Y
P73	GB	S&G	3	49	42	10	Y
P50	GB	T	2	69	26	5	Y
P64	GB	T	1	45	53	2	Y
P71	GB	T	2	47	44	9	Y
P68	GB	SS	1	52	43	7	Y
MEAN WEATHERED SAMPLES GREEN BAY LOBE				54.14	41.00	5.29	
P54	LA	S&G	4.5	72	28	0	N
P83	LA	S&G	6	36	28	16	N
P87	LA	S&G	6	34	50	16	N
P88	LA	S&G	2.5	39	54	7	Y
P98	LA	SS	4	37	46	18	N
MEAN LANGLADE LOBE SAMPLES				43.60	41.20	11.40	



Sample	% Sand	% Silt	% Clay	Magnetic Susceptibility
La-1-81	75	18	7	7.2
La-2-81	76	19	5	8.0

See drill log for 82 samples

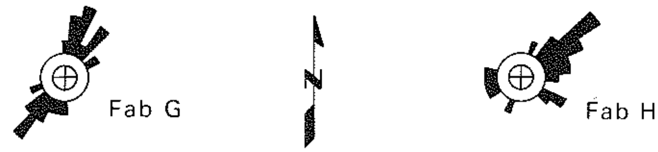


Figure 12. Description of Bogus pit site and rose diagrams showing the orientation of the long axes of pebbles in till and supraglacial poorly sorted sediment. The drill hole portrayed in figure 10 is at this location.

Sand and gravel occur throughout this physiographic region. The map of the county (plate 1) shows the distribution of sand and gravelly sand, and sandy gravel and gravel based on a relatively small number of observations. In general, outwash (sediment deposited by streams flowing away from the glacier) is the best sorted of the stratified units shown and has the most potential for concrete aggregate. Pitted outwash may be as well sorted, but there are commonly inclusions of till-like material that melted out of buried ice blocks. The most variable materials mapped as the sand and gravel facies are complexes of hummocky, collapsed, sand and gravel. Small areas of this type of sediment are also shown by symbols for eskers and parts of tunnel channel complexes in places in the Parrish and Summit Lake moraines. Although some clean sand and gravel deposits exist in this unit (primarily in eskers) most of these deposits are poorly sorted and commonly contain more silt and clay than does the outwash.

Zones of the Area Covered by Nashville Member

Moraine Zone.--The position of the maximum southwestward extent of the Langlade Lobe is marked by a discontinuous, single-crested ridge extending from just south of Parrish, in the northwest corner of the county, to about 3 km north of Polar, in the eastern part of the county. East of here it is buried by deposits of the Green Bay Lobe. This ridge is the outer edge of the Parrish moraine of Thwaites (1943). In this paper, the term "end-moraine complex" is used to designate the broad band of mostly till that formed parallel to the ice margin. It should be recognized that this is one of a complex set of individual landforms that formed in the moraine zone, and only the large areas of sediment other than till are shown on plate 1. The deposits of the moraine zone and areas behind were described by Nelson and Mickelson (1977) and their interpretation is reproduced here (fig. 16).

Along the southwest edge of the moraine zone is the outer moraine ridge itself. This fairly sharp-crested ridge is composed of uniform till and, in some places, poorly sorted supraglacial sediment. Good exposures at several localities where gravel pits or roadcuts intersect the ridge show that it is bounded by coarse, boulder and cobble gravel extending down a steep slope toward the southwest as an outwash apron. This apron is composed of some of the coarsest gravel in Langlade County, because streams issuing out of and off the ice built a stream bed with a steep gradient from coarse material that rolled or slid off the glacier front.

Table 8. Mean percentage of pink or orange feldspar in the very coarse sand fraction of selected samples of each unit.

Unit	Number of counted samples	Pink or orange feldspar as percent of total
Wausau till	9	3.3
Merrill till	9	2.9
Nashville basal till	15	3.4
Nashville supraglacial poorly sorted sediment	12	2.4
Mapleview basal till	4	18.1
Mapleview supraglacial poorly sorted sediment	9	18.4

Ridges composed of basal till that are parallel to former ice flow also occur in the end-moraine complex. Good examples of these are indicated as flutes on plate 1 in secs. 8 and 9, T. 32 N., R. 12 E. Many of the more-or-less equidimensional hummocks (small, steep-sided hills) in the end-moraine complex are also composed of uniform till under several metres of supraglacial mud-flow sediment. Two deep drill holes and sampling of outcrops suggest that the end-moraine complex is made up mostly of thick, uniform till beneath a generally thin but variable layer of crudely stratified sediments. One hole drilled on the west side of Highway S at SE1/4NE1/4SE1/4 sec. 8, T. 32 N., R. 12 E. penetrated to more than 40 m below the land surface. The upper 4 m (fig. 9) are sandy, poorly sorted material interpreted as supraglacial poorly sorted sediment. Below that, uniform basal till extends to 37 m below the surface. Sand and gravelly sand extends at least 4 m deeper.

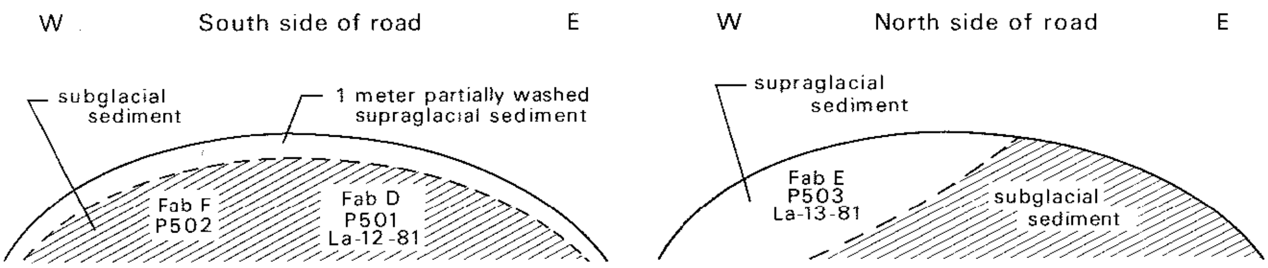
Another drill hole at NE1/4NE1/4NW1/4 sec. 27, T. 33 N., R. 10 E. penetrated 22 m of uniform basal till (fig. 10) before drilling stopped. Water-well records do not provide sufficient detail to evaluate the homogeneity of the materials, but the few that exist suggest a depth to bedrock in most of the end-moraine complex in excess 30 m (plate 1). Outcrops of Precambrian bedrock do exist along the Wolf River in part of the northern edge of the zone, so deposits are considerably thicker in the moraine zone than behind it (plate 1).

Although many of the equidimensional hummocks are composed of till, some, particularly the more elongate ones, are composed of poorly sorted sand and gravel and other supraglacial sediment. Many of these ice-disintegration ridges probably formed as crevasse fillings or as deposits of streams flowing under and between melting ice blocks. Although gravel in these ridges is suitable for gravel roads and perhaps asphalt, most deposits contain too much silt and clay and are too variable to be used as concrete aggregate.

Another landform in the ice-marginal zone is the ice-walled-lake plain. Several of these features are shown on plate 1. As glacial ice covered with some debris melted in this area, some spots, probably those where cracks or crevasses in the ice intersected ice melted faster and became lower than the surrounding ice. Water and sediment were then trapped in these large basins in the ice and lake sediment accumulated. Now that the ice has melted away, lake sediment caps hills surrounded by depressions that were formed by the melting ice blocks. Good examples of these ice-walled lake plains are in secs. 6, 7, 9 and 16, T. 33 N., R. 10 E. Most of these features are a quarter to one kilometre across and consist of sand and interbedded silt. Coarser sediment is present in ridges at the edge of some of the flat surfaces.

Behind the hummocky topography of the Parrish end-moraine complex is a zone of pitted and unpitted sand and gravel deposited as ice retreated and perhaps stabilized at the Summit Lake ice margin position (plate 1). Much of this sand and gravel between the Parrish and Summit Lake moraine complexes was deposited before ice had melted out of the deposits of the Parrish advance. In the central part of the county only the East Branch of the Eau Claire River cuts through the Parrish moraine and has unpitted terraces through the outwash of the Antigo Flats. In the northwest corner of the county the Prairie River also cuts through the Parrish moraine and has terraces of unpitted sand and gravel, indicating that buried ice of the Parrish advance had melted out, at that spot, before outwash stopped being carried down the Prairie River from ice to the north. For the most part, however, it appears that buried ice was present in front of the Summit Lake ice margin until ice retreat from this position and until after drainage from the ice was diverted toward the southwest in the Wolf River drainage.

Sand and gravel in the zone between the Parrish and Summit Lake moraines has variable texture. Fairly large areas (pitted gravel in plate 1) con-



Sample	% Sand	% Silt	% Clay	Magnetic Susceptibility
12-81	77	18	5	8.5
13-81	79	14	7	8.9

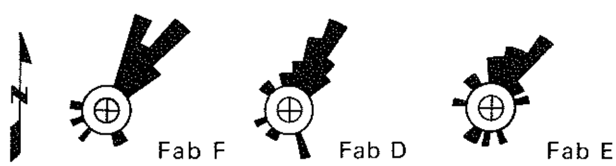


Figure 13. Description of Bogus sideroad site and rose diagrams showing the orientation of the long axes of pebbles in till and supraglacial poorly sorted sediment.

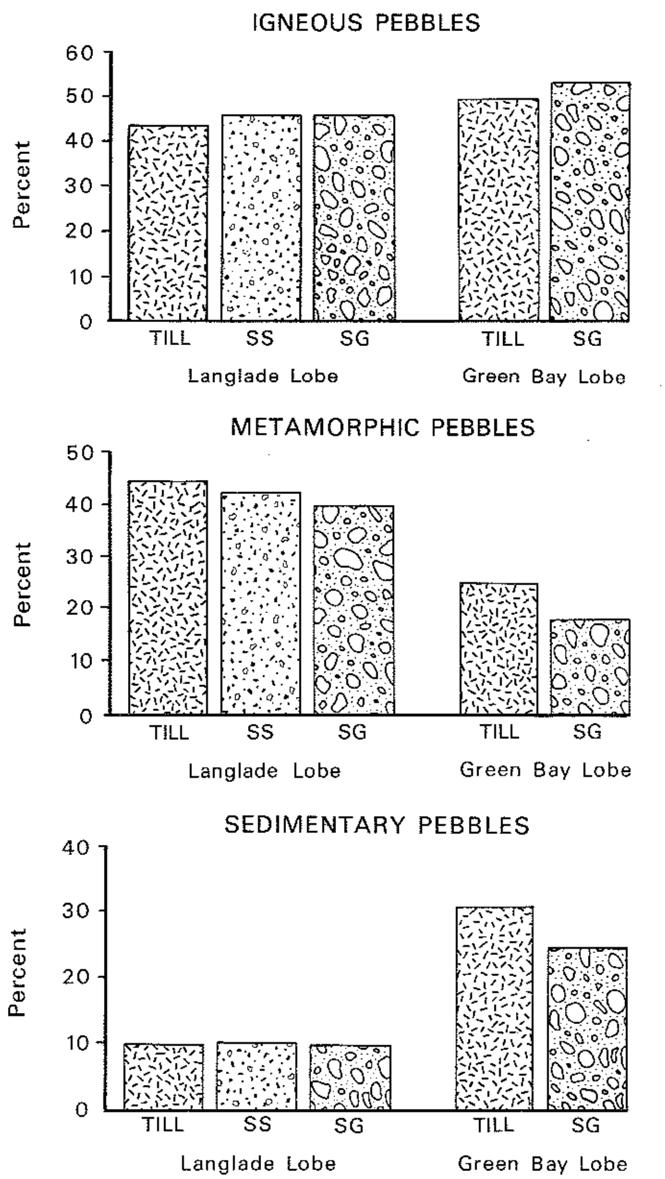


Figure 14. Histograms showing the percentage igneous (a), metamorphic (b), and sedimentary (c) pebbles counted in all unleached pebble count samples (tables 4, 5, 6, and 7); supraglacial poorly sorted sediment (SS), sand and gravel (SG).

tain coarse gravel with high infiltration capacity and with some future potential as a source of sand and gravel. Some land is suitable for agriculture but the surface generally lacks the silt cap that is present on the Antigo Flats and soils on positions high in the landscape are droughty.

The Summit Lake moraine (fig. 1) was recognized and described by Thwaites (1943), Nelson (1973), Nelson and Mickelson (1977), and Mickelson, Nelson and Stewart (1974). Relief of this moraine complex is very high in places (plate 1) because the Wolf River has downcut along much of its proximal side. In addition, it probably lies on a bedrock highland, at least in the central part of the county. In the northwest part of the county the Summit Lake moraine complex is a fairly narrow ridge that is composed, at least in part, of poorly-sorted sediment that is apparently supraglacial. This is more washed and more bouldery than the basal till, although as pointed out before, this difference is not very apparent in the lab data. The Summit Lake moraine complex widens toward the southeast and merges with deposits of the Parrish moraine in T. 32 N., R. 13 E. In the central part of the county and eastward to the vicinity of the Wolf River the moraine contains mostly supraglacial poorly sorted sediment at the surface although sorted material in the form of eskers and crevasse fillings are abundant in places. No ice-walled-lake plains or high-relief hummocky topography similar to the Parrish moraine complex are present. In general, land in this area is poor for agriculture. Surface boulders are abundant and steep slopes are common, making the land best suited for forest.

Deposits of the Summit Lake advance continue to the east as a hummocky complex of sand (plate 1; fig. 17) probably left as an interlobate deposit between the Langlade and Green Bay Lobes. This area consists mostly of sand deposits that have flat tops and are high in the landscape. Originally an extensive sand surface was deposited mostly on ice, by water from both lobes. Later, as ice retreated, buried ice melted from beneath the sand, creating deep depressions that surround uncollapsed areas. The high elevation of the uncollapsed surface (more than 30 m higher than sand and gravel less than 1 km to the south), indicates that the sand was deposited when Green Bay Lobe ice occupied all of the area to the south. The uncollapsed part of this formerly flat surface has a fairly thick silt cover (0.5 to 1 m) but the surrounding collapsed area is nearly devoid of a silt cap. This indicates that the surface was deposited fairly early during deglaciation and that subsequent collapse has dispersed or buried the former silt cap in collapsed areas. Lower surfaces in this landscape are droughty and have relatively poor soil, but the presence of the silt in the upland creates considerably better moisture and nutrient retention. In general, the area has very large infiltration capacity and little surface runoff.

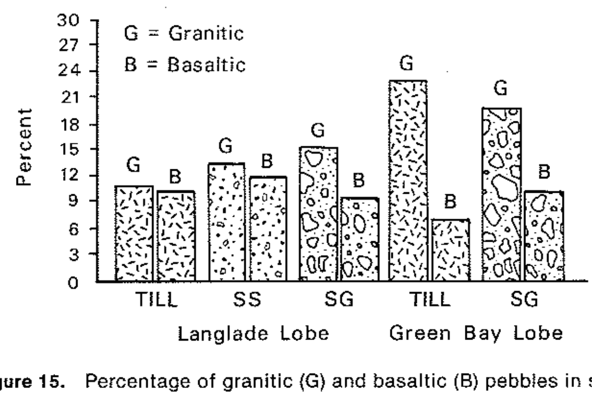


Figure 15. Percentage of granitic (G) and basaltic (B) pebbles in sediments of Langlade County; supraglacial poorly sorted sediment (SS), sand and gravel (SG).

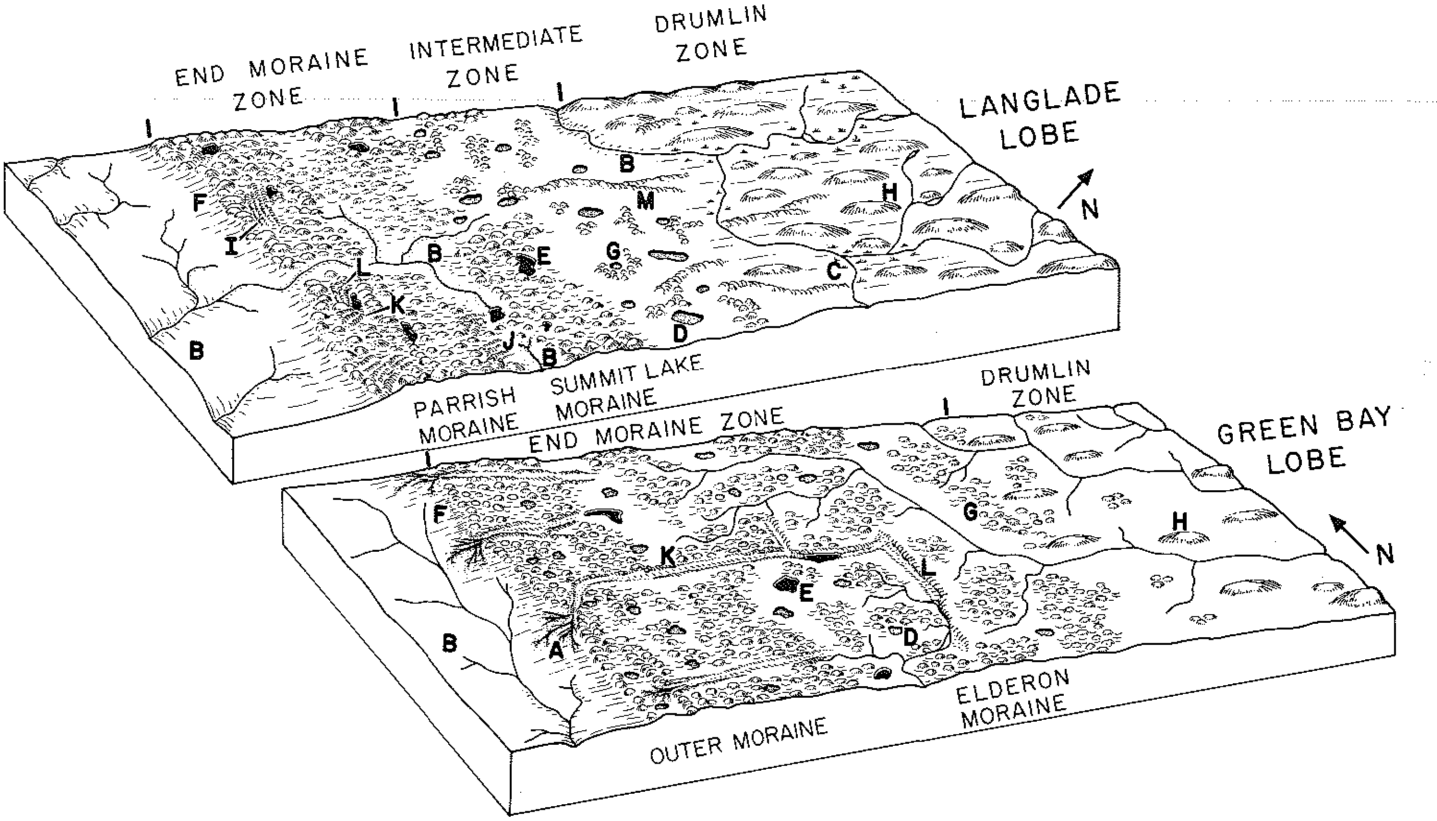


Figure 16. Physiographic diagrams of general landform distribution in the Langlade and Green Bay Lobes. The diagrams are not to scale, but illustrate the landform zones and features (referenced by capital letters) found in each lobe.

A. Outwash fan
B. Outwash plain
C. Marsh deposit
D. Kettle-hole (dry)
E. Kettle-hole lake
F. Outwash apron on moraine front
G. Kame
H. Drumlin
I. Ridges of till parallel to ice front (moraine ridge)
J. Small ridge of till perpendicular to ice front (flutes)
K. Short ridge of sand and gravel perpendicular to ice front
L. Short ridge of sand and gravel parallel to ice front
M. Long ridge of sand and gravel, winding or roughly perpendicular to the ice front (esker)

The Drumlin Zone.--Behind the Summit Lake moraine complex most till surfaces are streamlined in the direction of ice flow. Some of the individual hills are drumlins, but in many places the streamlining is indicated by what appears to be several small drumlins in a till upland. Although only about a quarter of this zone has till at the surface, these areas stand out because they are uplands surrounded by sand, sand and gravel, or organic deposits. Nearly all of the area shown as streamlined Nashville till on plate 1 contains uniform basal till at the surface that is usually at least several metres thick. Although similar streamlined topography to the north of Langlade County near Crandon and northeast near Wabeno in Forest County contains sand and gravel belonging to the Mapleview Formation within 2 or 3 m of the surface, this has not been observed in Langlade County. Characteristics of the basal till in this zone are the same as those described earlier in the section on the Nashville till.

Till of the Merrill Member is exposed at one locality in this zone (fig. 1, A). Along the west side of Highway T in NE1/4NE1/4SE1/4 sec. 2, T. 33 N., R. 11 E. till that closely resembles Merrill till (LA-4-83; Mickelson, 1987) is present beneath sand and probably beneath Nashville till.

Although no continuous ice-margin positions can be traced through this zone, several deposits are clearly related to the retreating ice margin. Low (10 m high) ridges are evidently small, single-crested moraines built by receding ice. These typically have some hummocky deposits of supraglacial till in and behind them and most are shown as Nashville supraglacial hummocky complex on plate 1. A good example is in secs. 27 and 28 of T. 34 N., R. 11 E. (fig. 18).

In a few other places, ice-margin positions are indicated by outwash heads or ice-contact fans. These are shown on plate 1 as Nashville gravel pitted fans. One example, located as shown in figure 19, shows a northwest-southeast trending ice-contact slope at the proximal edge of a fan built by water flowing from north to south away from the ice margin. Although these features

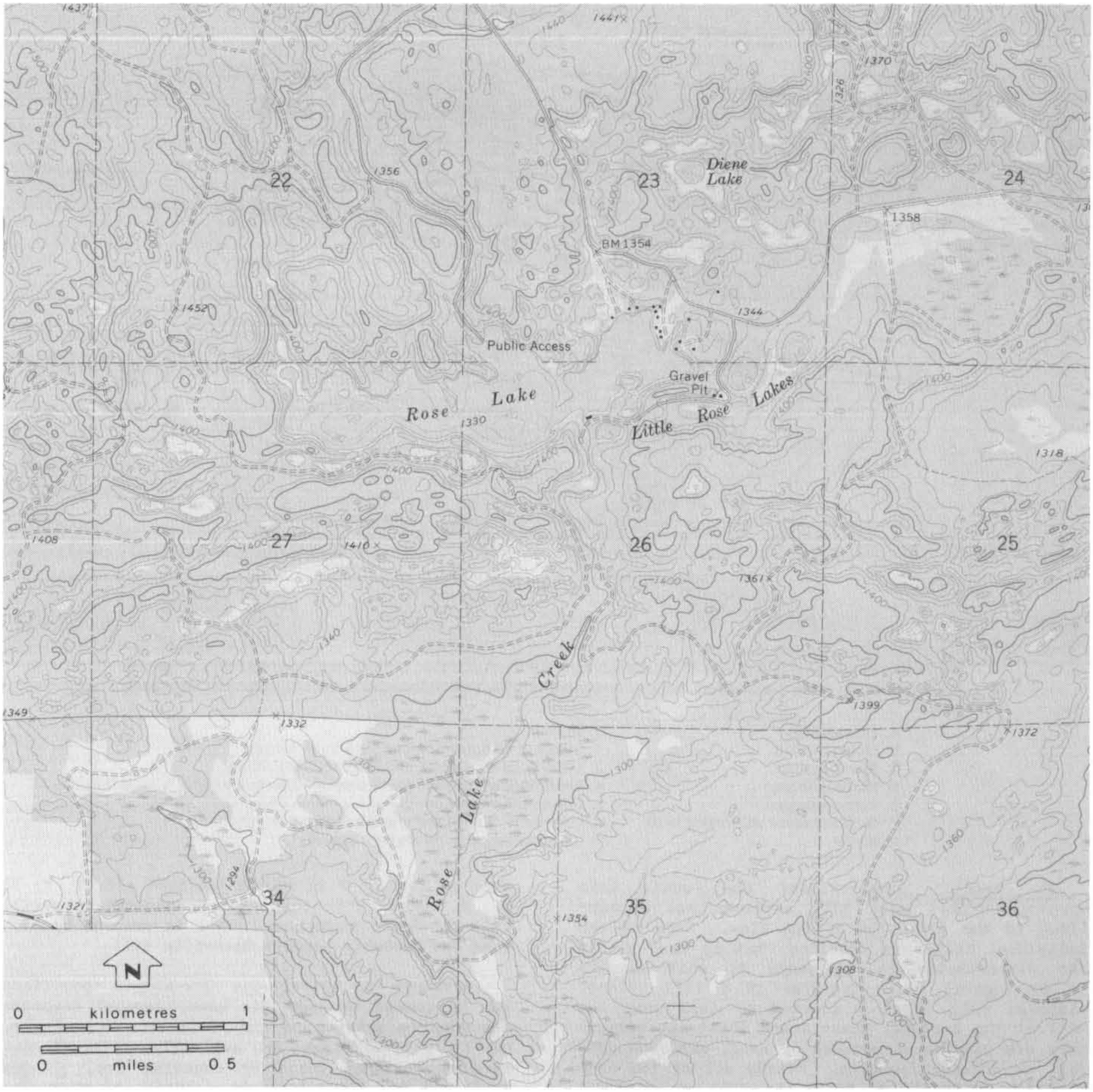


Figure 17. Map showing area of sand deposited as an interlobate deposit in T. 32 N., R. 14 E. Note high, flat surfaces underlain by sand indicating that ice of the Green Bay Lobe was present in this area at the time of the Summit Lake advance. Subsequent retreat of Green Bay Lobe ice allowed the building of fans along the southern edge of these interlobate deposits as water drained from melting buried ice.

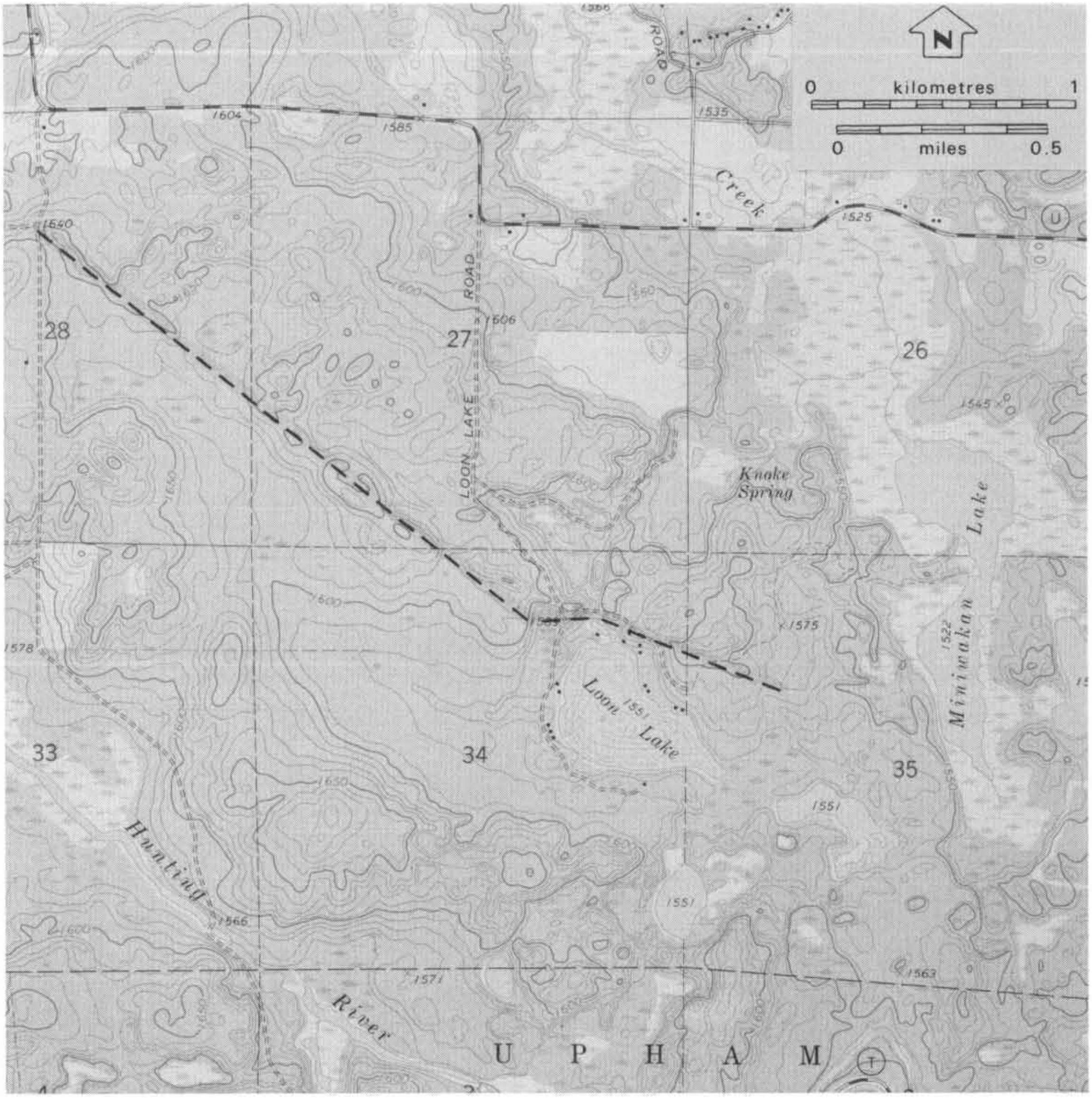


Figure 18. Moraine ridge of the Elcho advance. Located on the 7.5-minute Post Lake Quadrangle in T. 34 N., R. 11 E.

indicate the orientation of the ice margin during retreat, it is difficult to correlate them from one place to another and probably they do not indicate major readvances or even significant stillstands of the ice margin. The ice margin position shown in figure 19 is here called the Elcho ice margin position.

Various kinds of ice-contact sorted deposits occur in this zone. Several eskers, presumably deposited by streams flowing through tunnels beneath the ice, indicate that subglacial water flowed from the north or northeast toward the south or southeast. The eskers are composed mostly of gravel or sandy gravel and are generally good sources of aggregate. The largest esker in Langlade County is in secs. 26 and 34, T. 33 N., R. 13 E. near Lily. It is about 1.5 km long and contains sandy gravel of the Nashville Member.

Ice-contact sorted deposits also occur in hummocky complexes of sand and gravel. Because of the short distance of stream transport of this sediment and the rapidly changing environment of the glacier edge, the sediment is extremely variable. In general these deposits, shown as Nashville gravel hummocky complex on plate 1, are good local sources of gravel, but they cannot be depended on for uniformity of size or sorting. A good example of these deposits is shown in figure 20. Note that this deposit, like most, is higher than the pitted and unpitted outwash around it, and so can be mined without intersecting the water table.

An unusual deposit that formed in a similar way is Bear Caves, in eastern Langlade County. Located in SE1/4SW1/4NE1/4 sec. 29 T. 32 N., R. 14 E., it is a hill about 10 m across near the top and 100 m across near the base that is made up of

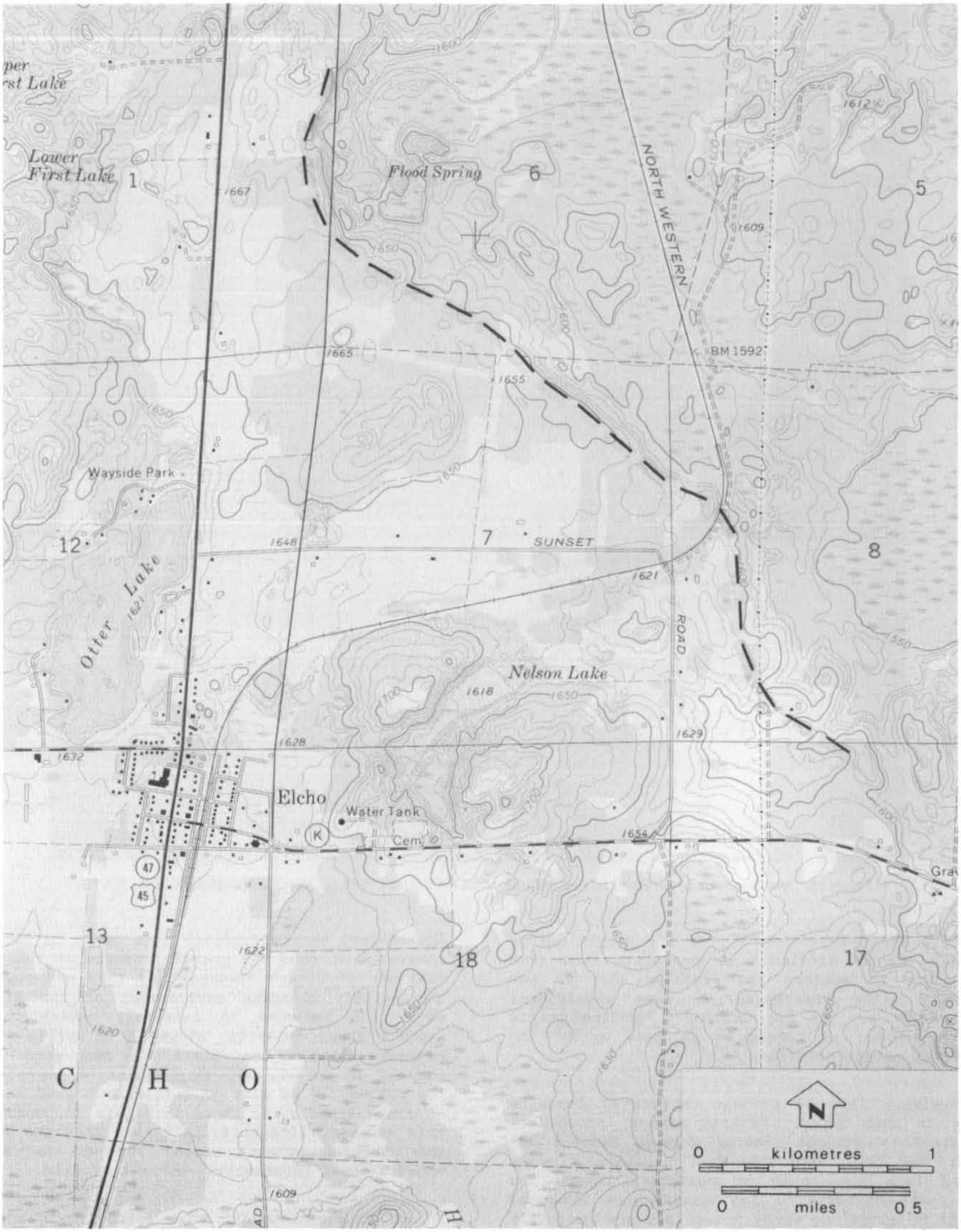


Figure 19. Ice-contact fan along margin of Elcho advance in T. 34 N., R. 10 and 11 E. Dashed line shows ice-contact face. Hill in the fan just east of Elcho is composed of till. Located on the Elcho 7.5-minute Quadrangle.

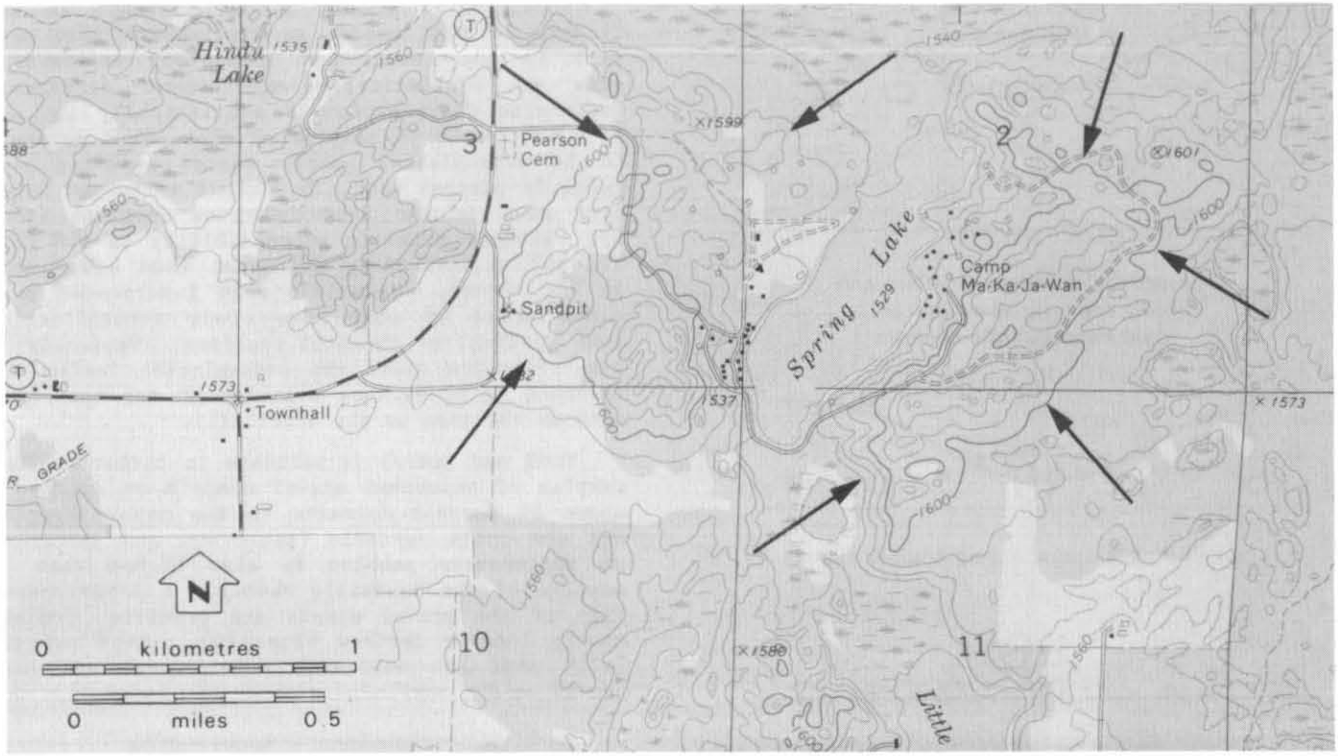


Figure 20. Hummocky complex of sand and gravel. Arrows point to deposit. Located in T. 33 N., R. 12 E. on the Pickeral 7.5-minute Quadrangle.

large boulders. All of these boulders are local granite and they are spherical and well rounded. They range in size up to about 3 m in diameter and have no gravel or even small boulders between. The boulder concentration probably formed when boulders were brought up into the ice by upward flow (fig. 21). If finer material was also brought up to the ice surface it was removed by streams, leaving only large boulders behind. These boulders then evidently rolled into a depression on the ice or a vertical hole through the ice. Smaller particles continued to be washed away from the boulders, perhaps by streams flowing into the ice. Eventually the ice melted away and a hill of boulders was left after the surrounding ice had melted out.

Most of the lakes and bogs in this zone are kettle holes produced by the melting of buried blocks of ice. During ice retreat sand and gravel often is deposited on parts of the glacier edge. When this happens, ice below is insulated and melting progresses slowly. The surrounding bare ice melts, leaving a landscape covered with sand and gravel deposited by streams flowing away from the glacier. These smooth, gently sloping streambed surfaces are then pitted when buried ice melts out and overlying sediment collapses. In areas where there was no buried ice, the flat surface remains. Pitted and unpitted surfaces are distinguished on plate 1. These deposits all have high infiltration capacity but some are suitable for agriculture, especially if fields are irrigated or if the surfaces stabilized early in the deglaciation process and therefore have a cap of windblown silt.

Area Covered by the Mapleview Member of the Horicon Formation

Description of Materials

The Horicon Formation is made up of till, stream deposited sand and gravel, and lacustrine sand, silt, or clay deposits of the Green Bay Lobe that are typically yellowish brown (10YR) and often sandy (except lake sediment) (Mickelson and others, 1984). In Langlade County the Mapleview Member is the only member of the Horicon Formation that was described and defined (Mickelson and others, 1984). Several types of sediment are recognized and discussed in this report.

The deposits of the Mapleview Member are between 22,000 and 12,000 years old and were deposited during the late Wisconsin Glaciation. Glaciers that deposited till of the Mapleview Member advanced from the southeast toward the northwest into the county. Unlike the Langlade Lobe, the Green Bay Lobe flowed across Paleozoic sedimentary rock and the till is therefore fairly rich in dolomite and sandstone where unweathered. The percentage of dolomite in the pebble fraction of all unleached samples collected in the Mapleview Member is about 25 percent, compared to less than 6 percent in the Nashville Member (table 4). Other differences in lithology are discussed earlier in this paper and are shown in figures 14 and 15 and tables 5, 6, and 7.

Ice flowing northwestward into Langlade County was flowing up a regional slope. Thus, glacial landforms of this lobe differ considerably from

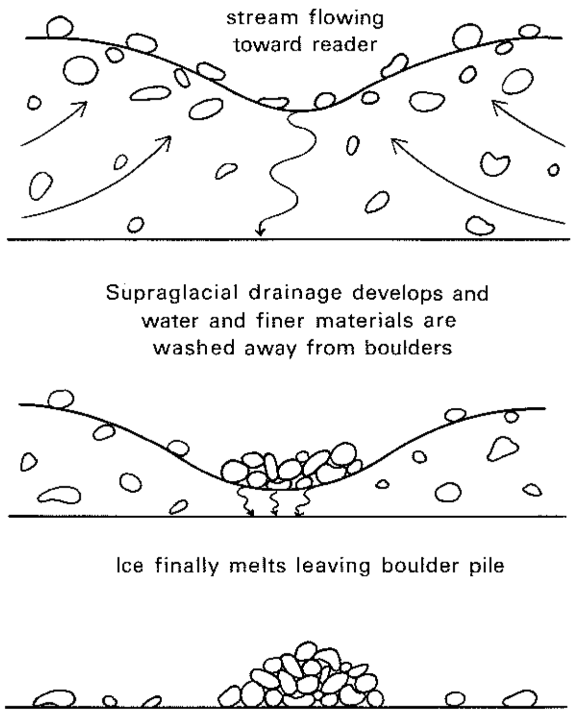


Figure 21. Possible mode of formation of Bear Caves in eastern Langlade County. Boulders accumulated on the ice surface and finer material was washed through holes in the ice, leaving only the largest boulders on the ice surface. These were then let down on the ground surface as ice melted.

those of the Langlade Lobe, which flowed down a regional slope. The outermost moraine in the southern part of the county, called the "Outer moraine" by Thwaites (1943), and the "Hancock moraine" by Clayton (in preparation) has the highest elevation of all Green Bay Lobe deposits (plate 1, cross sections). Behind this was built the second moraine (Thwaites, 1943) or what is here called the Hancock moraine (Clayton, in preparation). As ice retreated down the regional slope from the Hancock moraine, streams could not flow up hill to carry debris away from the ice. Instead, most sand and gravel was deposited by streams flowing southwestward parallel to the ice margin and it was often deposited on ice. Therefore, much of the till has been covered by outwash and only high drumlinized hills protrude above the outwash surface. The profile of the land surface (plate 1, cross sections 30 N,S; 31 N,S) shows a series of steps, many of which represent ice-margin positions. As described below, the grain size of sand and gravel deposits is related to these steps.

Basal till of the Mapleview Member is uniform, gravelly loamy sand or sandy loam that is usually yellowish brown (10YR). Twenty-five samples interpreted to be basal till average 82 percent sand, 13 percent silt, and 5 percent clay (table 3). Average magnetic susceptibility of the samples is 6.3, not significantly different than supraglacial poorly sorted sediment or those measured in the Nashville Member (fig. 5).

Supraglacial poorly sorted sediment is difficult, in some cases, to distinguish from basal till in the field, and laboratory measurements show no statistically significant difference. Grain-size distribution is statistically the same (fig. 3), with 16 samples of what was interpreted to be supraglacial poorly sorted sediment averaging 84 percent sand, 10 percent silt, and 6 percent clay in the less-than-2-mm fraction (table 3). Average magnetic susceptibility is 6.0 (fig. 5), not significantly different than other units in the county. Materials were interpreted to be supraglacial if they have crude stratification, some sorting, or abundant boulders. Typically the stratification makes the supraglacial facies more variable in appearance even though the mean grain size is the same as the basal till.

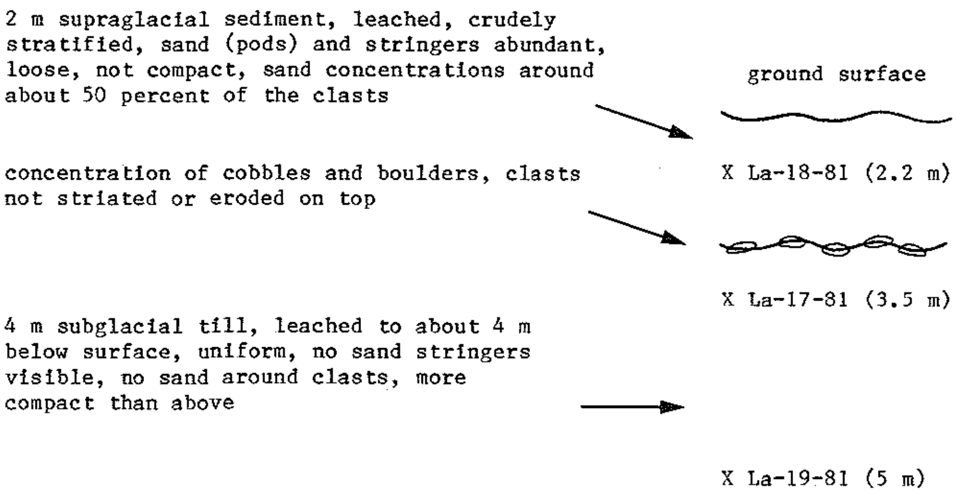
Sand and gravel is variable in texture. Three samples of unleached gravel contain an average of about 20 percent dolomite in the pebble fraction but are quite variable (table 4), and percentage of sedimentary pebbles is also higher than the samples of the Nashville Member. A large proportion of the gravel clasts are granitic, probably mostly locally derived (fig. 15). Sand and gravelly sand are separated from gravel and sandy gravel on the surficial geology map (plate 1).

Landform/Material Relationships

The Hancock moraine and Almond moraine are quite different in appearance and, perhaps, mode of formation from the Parrish moraine complex. They are single ridges from 0.5 to somewhat more than 2 km wide and are composed mostly of till in the upper 10 m. The few exposures in the moraines show less than 1 or 2 m of supraglacial debris over uniform basal till. One section, in the landfill in SW1/4NW1/4 sec. 11, T. 30 N., R. 11 E., is probably representative of much of the moraine. Here about 2 to 3 m of crudely laminated poorly sorted sediment overlies uniform basal till (fig. 22). The upper, crudely laminated sediment has approximately the same grain-size distribution as the till below, but the long axes of pebbles are less well oriented than in the lower till (fig. 22). Borings done for the landfill show uniform till to depth of about 30 m approximately the level of the adjacent outwash surface in front of the moraine.

One landform that is not present in the Langlade Lobe, but that is common in the Green Bay Lobe, is the path of former tunnel channels. Three are mapped in the moraine zone of the lobe in eastern Langlade County. These features are akin to features described by Wright (1973) in Minnesota, but are smaller and are partly filled with stratified deposits. An example of one of these former tunnel channels is shown in figure 23.

These channels were evidently formed by englacial and subglacial streams that collected water from beneath the Green Bay Lobe and carried it to the margin. Along its length the stream eroded a channel. In many places this channel was then partly filled with subglacial stream deposits, primarily sand and gravel. Where the tunnel was up in the ice instead of at the base, gravel was



Number	% Sand	% Silt	% Clay	Magnetic Susceptibility
La-18-91	77	16	7	9.3
La-17-81	81	13	6	9.9
La-19-81	77	18	5	8.9

Figure 22. Diagrammatic sketch of exposure in Antigo landfill (SW¼ NW¼ sec. 11, T. 30 N., R. 11 E.) showing type of sediment, location of samples and their size distribution, and the location of fabrics shown in figure 14.

deposited on ice, then let down as ice melted out. Sand and gravel that was not deposited in the tunnel was deposited in a fan (fig. 23) at the ice margin. Although in places the tunnel channels contain stream deposits, till also occurs in ridges along the edge of the channels. This may have been squeezed into the tunnel from below.

Behind the Hancock and Almond moraines most of the surface deposits are sand or sand and gravel. A few islands of basal till rise above the sand and gravel surface (plate 1, 30 N,S; 31 N,S). Ice-margin positions (fig. 1) are indicated by a zone of kettled, coarse sand and gravel and a marked step in the landscape. As mentioned above, the main reason for this is the regional slope toward the southeast, as shown in figure 24. Outwash streams could not carry water and sediment away from the ice margin toward the northwest, but instead water flowed toward the southwest, parallel to the ice margin. When the ice-margin position was stable for some time, sediment accumulated in front of and on the ice margin. Subsequent retreat of the margin left a step in the landscape (fig. 24). The outwash to the northwest of each of these steps generally becomes finer away from the ice-margin position.

Units mapped as gravel in plate 1 are generally suitable for coarse aggregate and are reasonably uniform in texture. No eskers or large areas of completely collapsed sorted sediment are present in this physiographic zone.

The cover of windblown silt is generally thin but variable. It is up to 1 m thick in places, particularly at the base of slopes. Outwash surfaces generally do not have much of a silt cap and are generally droughty. Nearly all surfaces have moderately large infiltration capacity.

Antigo Flats

The area known as the Antigo flats (fig. 2) is an outwash plain built by braided streams that flowed from ice of both the Langlade and Green Bay Lobes when they were at their maximum extent. Except in areas adjacent to the fronts of the Parrish, Hancock, and Almond moraines, the sand and gravel making up the outwash plain appear to be of mixed lithology, making it impossible to separate the Copper Falls and Horicon Formations, although sand-grain counts suggest that water from the Langlade Lobe dominated in depositing samples from three drill holes that were analyzed. Therefore, another map unit of undifferentiated sand or sand and gravel is mapped west of the Hancock and Almond moraines and south of the Parrish moraine. The sand fraction has less dolomite than the adjacent Horicon Formation and has more pink and orange feldspar than the Copper Falls Formation. The sand and gravel was presumably derived from both lobes, although water from the Langlade Lobe dominated as soon as ice began to retreat and water from the Green Bay Lobe began flowing southeastward parallel to the margin.

Adjacent to the moraines the land surface slopes fairly steeply toward the outwash plain. This outwash apron is made up of a series of small, coalescing fans of coarse gravel (up to 25 cm diameter). In a few places, particularly

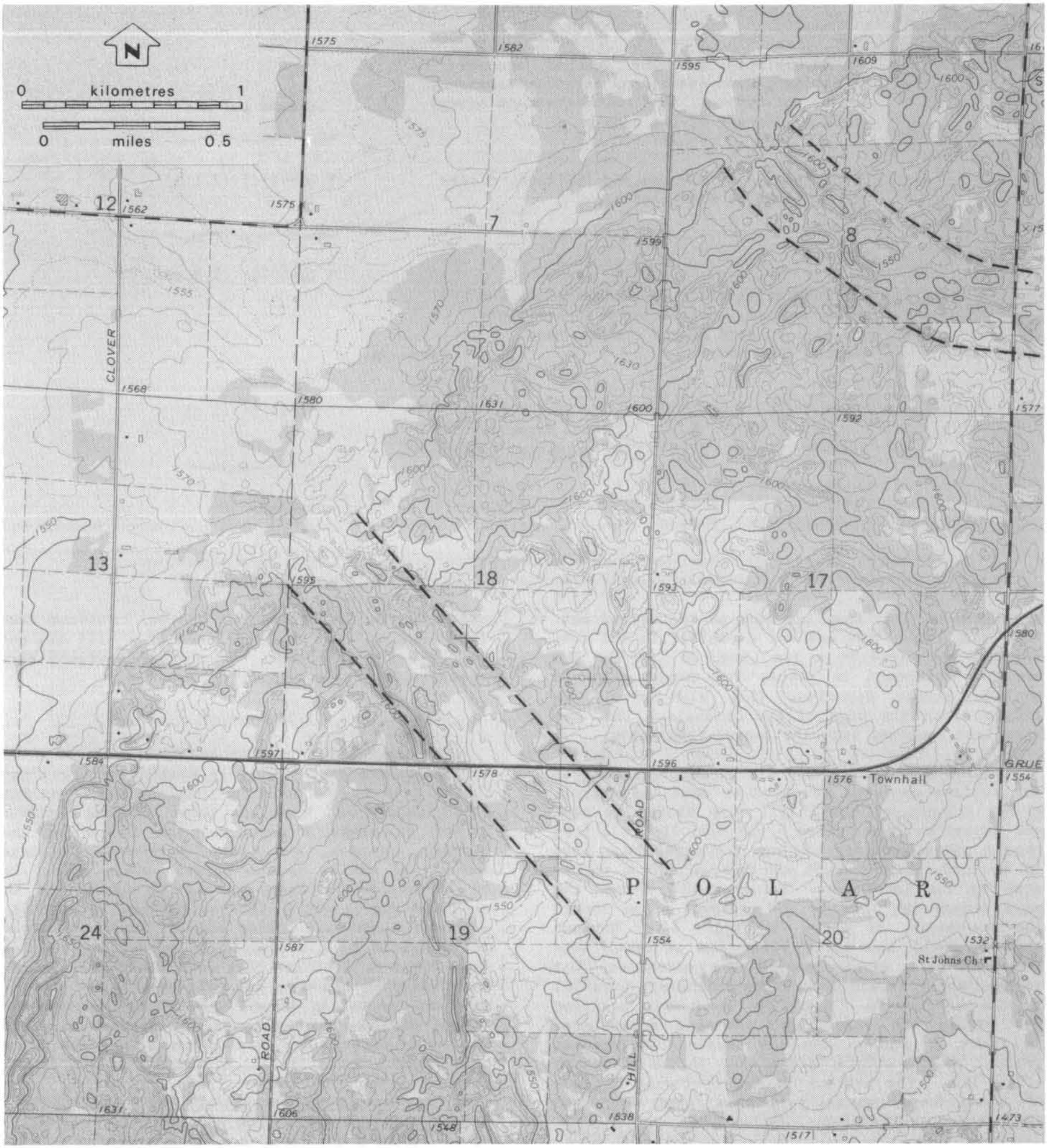


Figure 23. Tunnel channel (bounded by dashed lines) cutting outermost moraine of Green Bay Lobe and fan built in front of moraine.

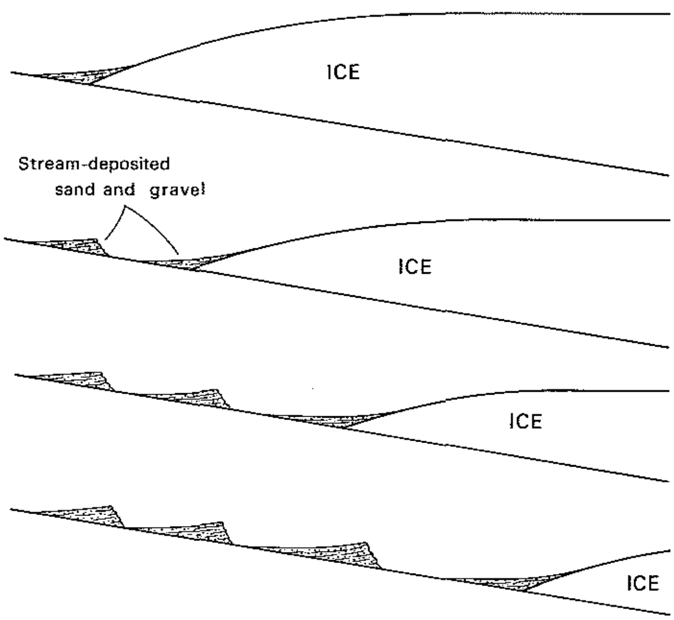


Figure 24. Diagrammatic sketch showing the formation of stepped landscape of the area covered by the Green Bay Lobe. Actual shape of land surface can be seen in plate 1, cross sections 31, N,S; 30 N,S.

along the Hancock and Almond moraines, large fans that extend further out into the outwash plain were built by large streams or rivers discharging out of or beneath the ice. These tunnel channels may have been very short-lived, but they discharged large amounts of sand and gravel onto the flats.

The grain size of sediment in the Antigo flats decreases rapidly away from the moraine front. More than 3 or 4 km from the moraine fronts most sediment more than 3 m below the surface appears to be sand and gravelly sand (plate 1, cross sections). Amounts of sand in each size fraction of samples collected from drill holes in the Antigo flats can be found in Mickelson (1987). Along the western edge of the Antigo flats, particularly in the southern part of T. 32 N., R. 10 E. and northern part of T. 31 N., R. 10 E. fine sediment (primarily silt and fine sand) indicates the presence of a lake that was dammed between the rising outwash plain and the rock upland to the west (plate 1, cross sections 32 S, 31 N).

In general, the bedrock surface drops from the west edge of the outwash plain to the east (plate 1, cross sections). In the southern part of T. 31 N., R. 10 E. rock is within 15 m of the surface. In the Antigo area and to the east and northeast the surface of the bedrock is considerably deeper.

Except very close to the front of the Hancock and Almond moraines there is no indication of early ice advance over this area, although the ice that deposited the Wausau till must have covered this area. There is no evidence of where the land surface was prior to the arrival of Green Bay Lobe at the Hancock moraine. The outwash plain probably began to develop at this time as water from both lobes flowed across the plain and southward through the Little Eau Claire River. Initially, the gradient of the streams must have been fairly low. At that time coarse gravel was dropped close to the ice margin and sand was carried in lower gradient channels across the outwash surface to where they converged in northern Marathon County. During early stages of outwash plain formation, there were probably two stream systems separated by the bedrock divide just west of Antigo (plate 1, cross section 32 S). The one on the west, in the present position of the East and West Branches of the Eau Claire River may have carried water only from the Langlade Lobe. East of the divide, in what is now the Spring Brook drainage basin, water almost certainly flowed from both lobes.

Because meltwater streams deposit most of their sediment near the source, close to the ice margin, the gradient of the streams would have steepened through time. Thus, the streams became more able to transport coarse sediment, and gravel was carried further from the moraines. There is a coarser cap of sandy gravel at least several metres thick over sand across most of the outwash plain. This coarsening upward must result from steepening stream gradient during building of the outwash plain.

As ice began to retreat from the Parrish, Hancock, and Almond moraines most drainage was diverted from the Antigo flats. In addition to water from buried ice in the Parrish moraine, the valley of what is now the East Branch of the Eau Claire River contributed to sediment on the Antigo flats. Pitted and non-pitted outwash in secs. 28, 33, 34, and 35 T. 33 N., R. 11 E. and the southwest part of T. 33 N., R. 12 E. and northwest part of T. 32 N., R. 12 E. was deposited by streams that then flowed through the Parrish moraine (fig. 25), probably on ice and frozen sediment. Through time, this less sediment-laden water probably began flowing in a single-channel and once outside the Parrish moraine, downcut through the already deposited outwash.

Buried ice in the Parrish moraine continued to melt out during this time, contributing small amounts of sediment to the outwash apron. These streams were not sufficiently large to flow across the outwash plain, and many began to flow parallel to the moraine front, cutting shallow channels.

This was particularly the case along the front of the Green Bay Lobe. As soon as retreat of ice began, drainage toward the west or northwest was blocked by the Hancock and Almond moraines. Subsequent melting of buried ice in this moraine produced water that flowed southward along the front of the moraines, cutting small channels parallel to much of the moraine front.

The last major geologic event on the Antigo flats was the deposition of wind-blown silt, or loess. This has a significant thickness (about 1 m) across most of the flats and is what makes the Antigo flats a rich agricultural area compared to areas that lack the silt cap. The fine-grained

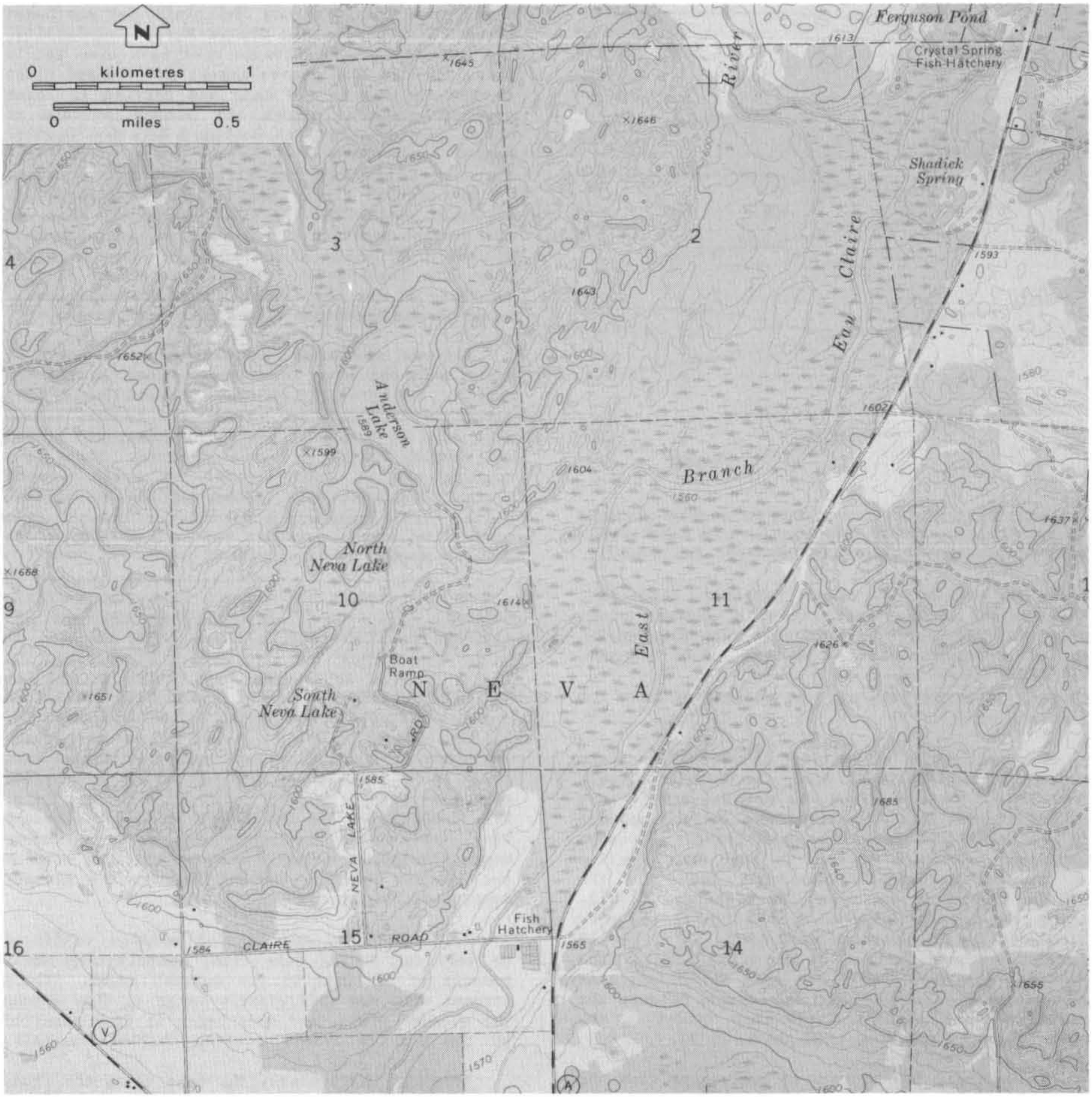


Figure 25. Map of the East Branch of the Eau Claire River where it passes through the Parrish Moraine (T. 32 N., R. 11 E.). Note that modern stream flows through peat that fills a former closed depression, indicating that buried ice or frozen debris was in this position when water was carried from the Summit Lake margin to the Antigo flats. Located on Pearson 7.5-minute Quadrangle.

particles of loess weather quickly producing nutrients, and silt and clay also have greater moisture holding potential and greater ion-exchange capacity than sand. Because of undulations on the surface of the outwash plain, small ponded areas were present, and some of the loess has crude stratification.

GLACIAL HISTORY

The earliest detailed study of the glacial history of north-central Wisconsin was by Weidman (1907), although Chamberlin had recognized the moraines in 1883. Weidman divided the deposits in front of the Outer and Parrish moraines into drift sheets that he labelled first, second, and third. Langlade County was entirely in the area of third drift. Subsequent to that, Hole (1943) studied the older till west of the Wisconsin River, concluding that distinction between older till units could not be made, and suggesting that the older till units might have all been deposited by one glacial advance.

LaBerge and Myers (1971) informally named the Wausau and Merrill tills in Marathon County. Stewart (1973), Mickelson, Nelson, and Stewart, (1974), Mickelson and Stewart, (1975), and Mode (1976) studied the composition of these tills primarily west of Langlade County, although some sites in Langlade County were sampled. The above workers conclude the following:

(1) The Wausau till is considerably more weathered than Merrill till, suggesting that it may be correlative with Illinoian or older deposits in Illinois.

(2) The Wausau till was deposited by ice flowing from the west-northwest.

(3) The Merrill till was deposited by ice flowing from the northwest.

(4) The Merrill till is less weathered than Wausau till but more weathered than till behind Parrish, Hancock, and Almond moraines. Radiocarbon dates on peat above the Merrill till of greater than 36,000 B.P. (ISGS-262) and 40,800 ± 2000 B.P. (ISGS-256) indicate that the Merrill till was probably deposited during the early Wisconsin Glaciation.

No new material for radiocarbon dating was found during this study, and because exposures of these units are poor in Langlade County, no major attempt to quantify weathering rates was made.

History of Late Wisconsin Advances

No radiocarbon dates of the advance of ice into Langlade County are available. Ice was reaching its maximum extent in Illinois by about 23,000 years ago, and it seems reasonable to assume that ice was present in Langlade County by about that time. Although we have no radiocarbon dates on late Wisconsin events in the county, it is possible to put together a more detailed relative chronology of events than can be done for the area outside the late Wisconsin moraines because glacial landforms are preserved. Limits can then be placed on the timing of events by comparison with events in other areas. Events described below were quite closely spaced in time and major event names should probably not be assigned to them.

Hancock Moraine – Almond Moraine – Parrish Moraine – Harrison Moraine Relationships

Probably the first glacial event of the late Wisconsin glaciation time in Langlade County was the advance of the Green Bay Lobe into the county from the southeast. The extent of the lobe was probably about to the present position of the Hancock moraine near Antigo and a few kilometres west of the Almond moraine in T. 32 N., R. 12 E. and northward to the present position of Crandon. Only two surface sites, both in T. 32 N., R. 13 E. show Mapleview till beneath deposits of the Nashville Member (fig. 1, points B and C). What is probably gravel of the Mapleview Member is present beneath Nashville till near Crandon (Simpkins, 1979) and in the vicinity of Mole Lake. Ice evidently retreated from the Hancock Moraine, readvanced to the Almond moraine (burying the Hancock moraine in most of the county) and began retreating before the Langlade Lobe ice advanced to the Parrish moraine (fig. 1). It seems likely that the Langlade Lobe ice advanced onto ice of the Green Bay Lobe in and behind the Almond moraine, but exposures are not abundant enough to document this. This area has higher relief hummocky topography than most of the Parrish or Almond moraines to the west or south.

In the western part of the county, the Wisconsin Valley Lobe reached its maximum extent at the Harrison moraine after ice had retreated from the Parrish moraine (Mickelson, Nelson, and Stewart, 1974). Nelson (1973) mapped deposits in this part of Langlade and adjacent Lincoln County and had three lines of evidence that lead to this conclusion. The orientation of elongate pebbles (till fabric) in what is interpreted to be basal till in both lobes shows no deflection of flow by the adjacent lobe (fig. 26). It seems likely that the lobes would have joined in an interlobate area if they had coexisted. Another line of evidence is the cross-cutting, abrupt contact between the Parrish and Harrison moraines (fig. 26). The third line of evidence is the existence of unpitted fans in front of the Harrison moraine but behind the Parrish moraine (fig. 27). These fans indicate that the area in front of the Harrison moraine was ice free when ice was melting out of the Harrison moraine. Evidence discussed below, however, indicates that there was some buried ice in the Parrish moraine long after this time.

Harrison Moraine – Summit Lake Moraine – Bowler Moraine Relationships

Ice had withdrawn considerably in the Wisconsin Valley Lobe by the time ice advanced to the Summit Lake moraine. Although detailed work has not been done in Oneida County, it seems

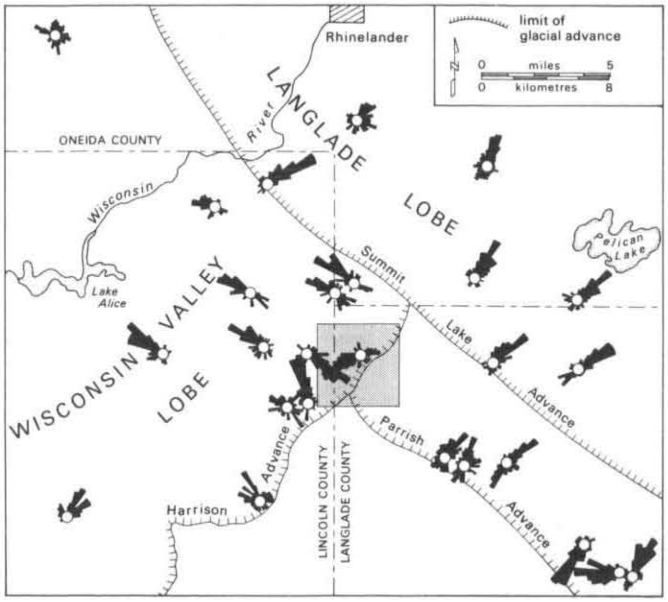


Figure 26. Map showing junction of the Wisconsin Valley Lobe and Langlade Lobe in northwest Langlade and adjacent counties. Pebble orientation shown in rose diagrams indicates no deflection of flow, indicating lobes were not at their maximum positions at the same time. Square shows location of map in figure 27. (From Newlson and Mickelson, 1974.)

likely that the Wisconsin Valley Lobe had retreated to the northern part of Oneida County or into Vilas County (Flambeau advance of Attig, 1984) by this time. Unpitted outwash exists along the front of the Summit Lake moraine in Lincoln County (Nelson, 1974) suggesting that most ice had melted in this area should be when ice advanced to the Summit Lake moraine. Drainage from the Summit Lake moraine was to the south in this part of Langlade County, and most water went into the Prairie River.

Further to the east, water draining the Summit Lake moraine deposited outwash (some of it pitted) as water flowed southeastward and northwestward toward the East Branch of the Eau Claire River. It seems likely that some buried ice or frozen debris was in the Parrish moraine at this time. Much of the valley through the moraine is low and peat filled (fig. 25). The edges of gravel terraces along the north and east sides appear to be ice-contact slopes and a terrace of unpitted gravel occurs on the west side, also with what appears to be an ice-contact slope.

Relationships between the Langlade Lobe and Green Bay Lobe at this time are complex and the interpretation varies considerably from that of Thwaites (1943). Thwaites suggested that the Summit Lake moraine was correlative with the Second (Almond) moraine. However, the Almond moraine is shown on figure 1 as overridding the Hancock moraine in southern Langlade County, and I interpret the Almond moraine to have been built before the Parrish moraine. What appears to be till of the buried Hancock moraine is shown in plate 1, cross sections 31 N., 31 S.

The interpretation presented here, somewhat modified from that of Mickelson, Nelson, and Stewart (1974), suggests that the advance to the Summit Lake Moraine was considerably later than the advance of the ice to the Almond moraine, and that the Green Bay Lobe had already retreated to the position of the younger Elderon moraines of Thwaites (1943) by the time of the Summit Lake advance.

Ice in the area where deposits of the Parrish moraine now cover deposits of the Green Bay Lobe must have had a considerable thickness of debris, and it seems likely that the advance to the Parrish moraine overrode stagnant Green Bay Lobe ice in the area just west of the outer Elderon ice-margin position, allowing the Langlade Lobe to extend somewhat farther southward than it did on the Antigo flats.

Mickelson, Nelson, and Stewart (1974) suggested that Langlade Lobe outwash was carried across Green Bay Lobe deposits in the vicinity of the Elderon Moraine because considerable parts of these channels are unpitted. Also, the outer edge of the east end of the Parrish moraine apparently overlaps an outwash channel in Green Bay Lobe deposits that is unpitted, also indicating that there was at least residual ice movement in the Parrish moraine after ice had abandoned the outer Elderon positions. Clayton (personal communication, 1984) reports at least six minor advances in the Elderon system in Portage County. These have

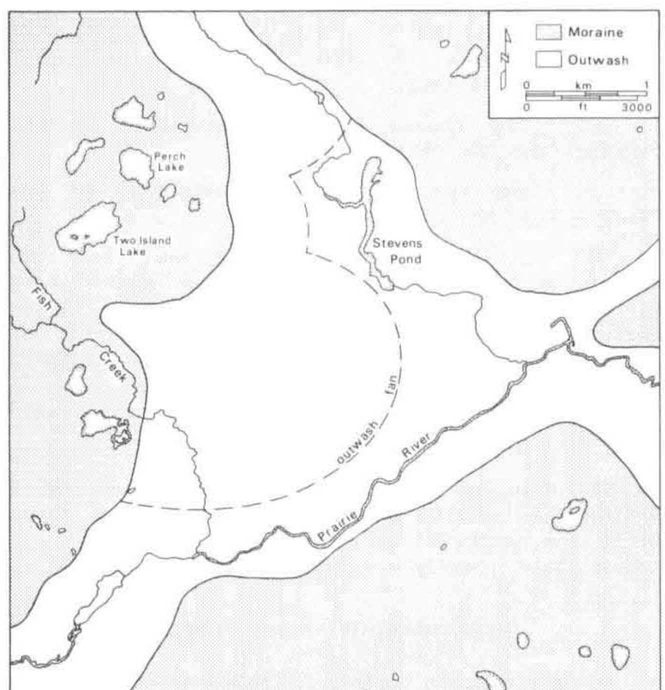


Figure 27. Junction of the Langlade and Wisconsin Valley Lobes in the vicinity of Parrish (T. 34 N., R. 9 E.). Note that unpitted fans leading from the Harrison Moraine indicate that ice had retreated from the Parrish Moraine before ice had completely melted out of the Harrison Moraine. See figure 26 for location. (From Nelson and Mickelson, 1974.)

not been traced to Langlade County, but it seems likely that earlier ones of these are correlative with retreat of ice from the Parrish moraine. The distribution of ridges in the Elderon system is shown in plate 1.

The Summit Lake moraine, especially in sec. 25, T. 32 N., R. 13 E. and secs. 26, 27, and 28, T. 32 N., R. 14 E. contains flat, unpitted sand that is well above the elevation of outwash to the south (fig. 17). This must mean that ice of considerable thickness was present in the Green Bay Lobe at the position of younger Elderon moraine ridges at the time of the Summit Lake advance. Water was dammed in the interlobate area, and sand was deposited at a high elevation. Subsequently, buried ice melted out from beneath much of the sand, causing the sand to collapse and producing fans along the southern edge of this interlobate moraine (fig. 17). The channels of Dalton and Rose Lake Creek were formed at this time by meltwater from buried ice.

Later Advances

A later advance of the Green Bay Lobe produced the Bowler moraines of Thwaites (1943) in the southeastern corner of Langlade County (fig. 6). Evidently ice at this time was still buried in the Summit Lake sand deposits discussed above. An extensive outwash surface formed along this ice front as water flowed along the ice margin toward the southwest. Small ridges were built in the marginal zone but there is little till and the marginal zone is indicated by a collapsed gravel zone considerably lower than areas to the west (plate 1, 31 S).

Thwaites (1943) also mentioned the Elcho moraine in Langlade Lobe. This feature is marked by a complex of supraglacial deposits with a distinct marginal ridge in secs. 27 and 28, T. 34 N., R. 11 E. (fig. 18) and an ice-contact slope along the head of a large fan (fig. 19) in sec. 1, T. 34 N., R. 10 E. and secs. 6, 7, and 8 of T. 34 N., R. 11 E. This ice-front position cannot be traced further south because it appears to merge with deposits of the Summit Lake moraine. It may be that this advance is correlative with the Bowler advance in the Green Bay Lobe although this is not conclusive.

No radiocarbon dates document when glacial ice finally left Langlade County, but it was probably between 13 and 14,000 years ago. Since that time streams and minor landslides have reworked sediment in the landscape and peat has accumulated in many low areas. However, evidences of former glaciation still dominate the landscape.

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