Preliminary surficial geologic map of the Iron River $1^{\circ} \times 2^{\circ}$ quadrangle, Michigan and Wisconsin

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This report is preliminary and has not been reviewed for conformity with U.S. Geological Survey editorial standards and stratigraphic nomenclature.

INTRODUCTION

The Iron River 1^{o} X 2^{o} quadrangle straddles the border between northern Wisconsin and upper Michigan. It has an area of about 6700 miles^2 (17,300 km^2) of which about 900 miles^2 (2300 km^2) are fresh water lakes. The land surface is generally 1500 to 1750 feet (457 to 534 m) above sea level in the southern part of the quadrangle. It drops in the northern part down to the level of Lake Superior, mean level 682 feet (208 m). The northern half of the quadrangle is drained mainly by the Presque Isle, Ontonagon, and Sturgeon Rivers, which flow northward into Lake Superior. The southeastern part is drained mainly by the Iron and Paint Rivers, which flow southward to Green Bay. The southwestern part is drained mainly by the Wisconsin and Manitowish Rivers, which flow to the Mississippi River. The major drainage divides are shown in figure 1.

The glacial geology of the Michigan part of the quadrangle has been mapped and described by Leverett (1929). The Wisconsin part is shown on the glacial map of Wisconsin compiled by Hadley and Pelham (1976). Black (1969) discussed the drift in parts of the quadrangle and traced the border of the Valderan deposits across the quadrangle. Hack (1965) mapped and discussed glacial flutes and shorelines of former glacial lakes, and described the glacial deposits, in the northwestern part of the quadrangle.

In all, 6-1/2 months were spent doing field work in the quadrangle during the summers of 1978, 1979, and 1980. Field work consisted mainly of driving out the passable roads and examining the drift in the roadcuts and in the sand and gravel pits. Because of the extensive forest cover, identification and mapping of the glacial landforms had to be done mainly by interpreting the 1:62,500- and 1:24,000-scale topographic maps and the 1:80,000-scale aerial photographs.

Parts of two of the Huron Islands (only one is shown on the map) are in the northeast corner of the quadrangle. These islands were not visited and are not mapped.

BEDROCK SURFACE AND THICKNESS OF DRIFT

The altitude and configuration of the bedrock surface is poorly known because it is mostly covered with glacial drift, and the recorded drill-hole information is sparse. Figure 1 shows the major bedrock units generalized from W. C. Cannon (written commun., 1982). The existing drill records and surface observations, however, indicate that the surface of the bedrock is quite rough and must have a local relief of 50 to 100 feet (15 to 30 m) in much of the quadrangle and 650 feet (200 m) or so in the mountainous areas. The thickness of the drift is poorly known but probably ranges mostly between 0 and 150 feet (0 and 45 m) and is quite variable over short distances. The maximum thickness of drift recorded in county water reports is 370 feet (113 m) on the north side of Bruce Crossing, Mich. (Doonan and Henrickson, 1969).

The surface of the bedrock shows evidence of ice erosion. The large-scale bedrock topography near Keweenaw Bay has been shaped by overriding glacial ice. The large southwest-trending streamlined hills northwest of Baraga, Mich., and the oval-shaped hill southwest of Rock Beach Point on the east side of Keweenaw Bay are rock drumlins and were ground to their present shape by overriding ice. The Abbaye Peninsula, between Keweenaw Bay and Huron Bay, and the southwest-trending streamlined hills southeast of Huron Bay have also been shaped by overriding ice. These large streamlined features probably occur here because the underlying Jacobsville Sandstone was particularly subject to ice erosion, and because the original topography was alined parallel to the direction of ice movement.

The surface of resistant bedrock such as granite gneiss and metagraywacke is found to have been ground smooth by overriding ice wherever it is exposed. The surface on weaker rocks such as the Freda and Jacobsville Sandstones, where observed in several places, was not smooth but rather appeared to be gradational from firm rock into the macerated rock which formed the overlying red till.

GLACIAL LOBES

The Iron River quadrangle was the site of the coalescence of ice lobes which emerged from the Lake Superior basin and the Green Bay trough and which acted independently or semi-independently. The westernmost lobe came south from the western part of the Lake Superior basin. It was separated from the ice in the eastern part of basin by the Keweenaw Peninsula (fig. 2). This ice mass is herein named the Ontonagon lobe after the village of Ontonagon, Mich., on Lake Superior. Another independently acting ice mass moved westward and northwestward out of the Green Bay trough and the low ground between Green Bay and Lake Superior, and it is known as the Green Bay lobe. Between the Ontonagon lobe and the Green Bay lobe an independently acting ice mass pushed southwestward out of the eastern part of the Lake Superior basin. This ice mass has been called the Langlade lobe particularly where the ice front stood south of the quadrangle. Where the ice front stood near the shores of Lake Superior, the Langlade lobe was represented by two ice masses: that of the Keweenaw Bay lobe which moved southwestward out of the Keweenaw Bay lowland; and an ice mass herein named the Michigamme lobe after Lake Michigamme, that moved southwestward across the area between Marquette, Mich., and the Huron Mountains (fig. 2). The ice lobes named here, the Ontonagon lobe and the Michigamme lobe, are in part similar to lobes named by Black (1969). However, because of significant differences in interpretation, new names are used in this report rather than using Black's names in a different way.

The name Ontonagon lobe is used here to refer to glacial ice that retreated across the southwestern part of the quadrangle south of the Winegar moraine, as shown in figure 3A. Glacial ice that traversed the same area prior to the retreat of the ice lobe probably extended southward to form part or all of the Wisconsin Valley lobe (fig. 2) and, thus, the ice could as well have been called the Wisconsin Valley lobe.

AGES OF THE DRIFT

The exposed glacial deposits in the quadrangle are all of late Wisconsinan Age, Woodfordian and younger. The edge of Valderan deposits has been located within the quadrangle by Black (1969). However, because of controversy regarding the stratigraphic position of the "Valders" till relative to the Two Creeks foreset bed (Mickelson and Evenson, 1975; Black, 1980), no attempt was made to locate the edge of the Valderan or Greatlakean (Evenson and others, 1976) deposits for this map. Mickelson and McCartney (1980) and McCartney (1980) suggested that the outermost red till of the Green Bay lobe some 45 miles (70 km) south of the Iron River quadrangle is of "Port Huron" age. The western edge of the Sagola moraine probably corresponds to this red till. Therefore, the Winegar, Saint Johns, and Sagola moraines (fig. 4), which are about the same age, may be the same age as the Port Huron moraines (about 13,000 years B.P.), With considerable difference in detail, this same correlation was made by Leverett (1929, pl. 1 and fig. 5).

Several pieces of ancient wood, which have radiocarbon ages clustering around 10,200 years B.P., were found in the glacial deposits in the northwestern part of the quadrangle and in areas slightly to the west. Most of the locations were shown by Black (1976). Wood from the Ontonagon Plain was reported by Hack (1965) to have an age of 10,230±280 years B.P. (W-964). Meyer Rubin (oral commun., 1981) determined the age of wood that he found buried beneath red till just west of the Porcupine Mountains (sec. 14, R. 45 W., T. 50 W.). Two samples of this wood have dates of 10,100±250 years B.P. (W-1540) and 10,250±250 years B.P. (W-1541) which were determined at the U.S. Geological Survey Radiocarbon Laboratory in Washington, D.C., in 1964. Some problems with interpretations of radiocarbon dates from this area were discussed by Black (1969, 1976), but clearly at least part of this wood is in or immediately beneath red till, indicating that the Ontonagon lobe must have advanced out of the Lake Superior basin into the northern part of the quadrangle about 10,200 years ago.

Hughes and Merry (1978) reported that wood which was buried by outwash from near Marquette, Mich., has a radiocarbon date of 9,850±300 years B.P. They proposed that an advance of glacial ice out of the Lake Superior basin and into the Marquette area occurred at that time, and they named this advance the "Marquette Stadial." This advance is judged to be the same as the latest one into the Iron River quadrangle that is discussed above.

TILL

Till within the quadrangle has variable color and grain size. Much of the till has a distinct reddish color (close to moderate reddish brown, 10R4/4) (Goddard and others, 1948) and is called red till in this report. The grain-size distribution within the red till of the less-than-2-mm fraction ranges from mostly medium-grained sand to mostly silt and clay. The red color is carried by the finer grained material, probably mostly the clay-sized grains. Distribution of the red till in the quadrangle is shown in figure 4. The red components of the tills deposited by the Ontonagon lobe and the Keweenaw Bay lobe are probably derived from the red sandstones and shales that underlie the glacial deposits (see fig. 1) in the northern part of the quadrangle. Tills in areas such as near Baraga and L'Anse, Mich., that lie directly on the Jacobsville Sandstone appear to have about the same grain-size distribution as the Jacobsville, which is a red medium-grained sandstone near L'Anse. Likewise, the red tills that lie on the Freda Sandstone appear to have the same grain-size distribution as the Freda, which is a red fine- to very fine grained sandstone near Ontonagon, Mich. In some places, the tills, which contain numerous fragments of bedrock are difficult to differentiate from bedrock that has partially disintegrated *in situ*.

Red tills lying directly on red bedrock of similar grain size were derived from the red bedrock. Elsewhere the connection is less certain. For instance, much clayey till occurs in the Watton moraine, particularly north of Watton, Mich. This grain-size distribution is not similar to that of any local bedrock. However, it is similar to that of the red glacial-lake silts and clays found in the north-central part of the quadrangle. Probably before the Watton moraine was deposited, the front of the Keweenaw Bay lobe retreated northeast beyond the position of the Watton moraine and a glacial lake formed west of that glacier. In this lake, red glacial silt and clay were deposited. The red silt and clay were probably the finest part of the pulverized Jacobsville Sandstone. The Keweenaw Bay lobe subsequently picked up these clays and silts when it readvanced and deposited them in the Watton moraine. These lake clays may not have been moved far. This mode of origin of clayey red tills in the Lake Superior basin has been suggested by Wright, Matsch, and Cushing (1973).

The red till in the Winegar moraine is quite far removed from red-colored bedrock. Probably only a small percentage of red sediment, however, is required to color the till. This sediment could be carried for many kilometers by the glacial ice and, thus, red till could be deposited at a distant site. Alternatively, red silt and clay could have been deposited north of the Winegar moraine during a previous retreat and subsequently picked up by the next ice advance, mixed with coarser material, and deposited in the Winegar moraine.

The red till deposited by the Green Bay lobe is probably colored by red sediment carried out of the Lake Superior basin by glacial ice moving southward across the low ground between Lake Superior and the north end of Green Bay and then westward into the quadrangle. Or, possibly, red sediment was washed southward by glacial streams and then moved westward by the Green Bay lobe.

Gray and brown tills which are sandy and stoney, also occur in the quadrangle (fig. 4). The color of the gray till is close to light olive gray (5Y5/2) on the rock color chart; the color of the brown till is close to moderate brown (5YR5/2). Color names are from Goddard and others (1948). The collective distribution of the two tills is shown in figure 4; individual distributions are poorly known. Commonly they are closely associated, and the colors in some places have a patchy distribution within the drift. In some places, the brown till may be an oxidation product of the gray till. However, in most places, the distribution of the tills suggests that this cannot be true. For instance, in the vicinity of Iron River, Mich., the till is all brown; 9 miles (14.5 km) to the northwest, it is virtually all gray though it has similar grain size. The brown till is probably not oxidized gray till. The gray color may be cased by incorporation of pulverized Michigamme Formation (fig. 1), which contains abundant gray graywacke and black slate. The brown color in the till near Iron River, Mich., may be caused by incorporation of the iron ores that occur locally. However, what is known about the distribution of the brown color and about the direction of latest ice movement does not correlate particularly well with this mode of origin.

SHORELINES OF GLACIAL LAKES

Several shorelines of glacial lakes that occupied the Lake Superior basin were located by Leverett (1929). The most detailed and most recent work, however, is by Hack (1965) who located and discussed the shorelines north of, and within, the Copper Range and in the environs of the Porcupine Mountains (see fig. 1). No attempt is made to locate the shorelines for this map; Hack's map (1965, pl. 1) covers most of the area where shorelines are well developed. The best developed ancient shoreline (Lake Nipissing shore) occurs about 16 feet (5 m) above the present shore of Lake Superior (Hack, 1965). Most of the windblown sand and beach deposits mapped along Lake Superior were deposited along this shore. The next best developed ancient shoreline is recognizable in many places on topographic maps and occurs at about 1200 feet (365 m) altitude northeast of Greenland, Mich. This shoreline descends westward along the north sides of the Copper Range and the Porcupine Mountains to about altitude 1150 feet (350 m) at the west border of the Iron River quadrangle. This is the highest well-developed shoreline and was formed by a glacial lake (Lake Duluth) that was ponded by glacial ice in the Lake Superior basin during the waning of the last ice advance (fig. 3H). This lake drained westward through the St. Croix Valley (Leverett, 1929). Between these conspicuous shorelines are several that are less well developed, which were plotted by Hack (1965).

TERMINUS OF THE LATEST ADVANCE OF THE ONTONAGON LOBE

No uniquely identifiable moraines associated with the last advance on the Ontonagon lobe (about 10,200 years B.P.) have been identified. However, the ice mass probably advanced southward to the approximate limit shown on the map. The streamlined nature of the topography, including the glacial flutes and the smoothed-out valleys and interfluves found north of the terminus indicate its plotted location. The Sixmile moraine and the Rousseau delta must have been deposited during this latest advance. However, the top of the Rousseau delta must have been deposited after the Ontonagon lobe had retreated from its maximum extent, or the lake water could not have escaped along the path shown in figure 3G and thus maintained a shoreline altitude of about 1200 feet (366 m).

ECONOMIC DRIFT DEPOSITS

The drift in the quadrangle is used primarily for road metal and road fill. Much of the drift including the till is used without any preparation. In other cases, particularly where the drift is used to surface gravel roads, it is sieved and crushed to a gravel having a fairly restricted size range. The descriptions of the various units identify the dominant material types within the map units. The drift within many of the end moraine units, "thin drift over bedrock" units, and ice-contact stratified drift units is rather heterogeneous. Commonly at least some digging is required to identify the material type that lies beneath the surface.

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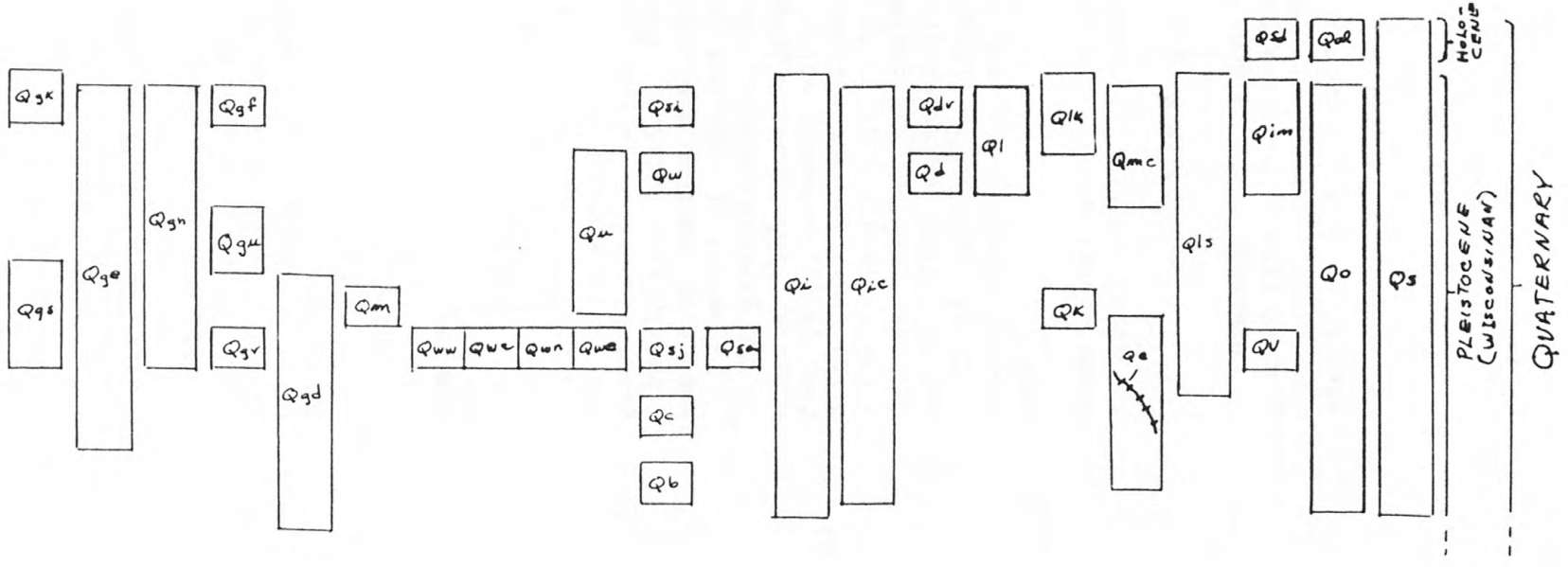
Peterson - Iron River quad, MI-WI

CORRELATION OF MAP UNITS OF SURFICIAL DEPOSITS



DESCRIPTION OF MAP UNITS

POST GLACIAL DEPOSITS

Qal — Alluvium (Holocene) -- Mostly yellowish-gray, medium-grained sand. Only wide areas of alluvium are mapped

Qsd — Windblown sand and beach deposits (Holocene) -- Mostly yellowish-gray, medium-grained sand that forms narrow elongate dunes less than 6 feet (2 m) high. The dunes parallel the shores of Lake Superior. The sand was derived from beach sand which occurs only in a narrow beach at the waters edge in most areas. Most or all of the mapped deposits are related to Lake Nippissing and Lake Superior (Hack, 1965, p. B7). Thin and patchy unmapped deposits of medium-grained sand also occur on the northern edge of the Ontonagon Plain as far as 2.5 miles (4 km) inland from the mapped deposits.

Low sand dunes derived from medium-grained lake-sands are found on the relatively flat area called the Baraga Plains. Low dunes derived from medium-grained glaciofluvial sands also occur in places east of the Crystal Falls moraine. The dunes are unmapped because the extent of the dune topography is not known.

A veneer of unmapped windblown sand is commonly found on the glacial deposits that are older than the Watton moraine. This deposit ranges in thickness up to about 3 feet (1 m), commonly being about 1.5 feet (0.5 m) thick. It is commonly composed of fine- to medium-grained sand, which is rarely silty. It almost invariably contains pebbles, cobbles, and boulders floating in the sand matrix. This admixture of stones is probably the result of frost heave which lifted the stones from the top of the glacial deposits into and onto the veneer of windblown sand

Qs — Swamp deposits (Holocene and Wisconsinan) -- Chiefly peat and muck, and minor amounts of silt, sand, and clay

END MORAINES (WISCONSINAN)

Hummocky elongate bodies of drift deposited at the glacier fronts when they remained about stationary for considerable periods of time. Composed of till and stratified drift, commonly strongly collapsed

Qc

Crystal Falls moraine -- Composition very poorly known, mostly medium-grained sand in roadcuts, which may be a windblown veneer from sand deposits to the east; small exposures of pebble gravel and gravelly sand. The area is hilly, similar to that found immediately to the west of the moraine but with a hummocky topography of smaller relief superimposed on the surface. Many of the hills are probably bedrock with a veneer of drift. Deposited by the Green Bay lobe. Named for Crystal Falls, Mich.

Qww
Qwc
Qwn
Qwe

Winegar moraine -- Qww -- Mostly ice-contact stratified sand and gravel and calcareous red sandy till; strongly collapsed hill and swale topography with abundant depression containing swamps and lakes many of which are interconnected; numerous short ridges which appear to be ice channel fills. The moraine has a well-defined front, which rises as much as 115 feet (35 m) above the drift to the south. Deposited by the Ontonagon lobe.

Qwc -- Mostly stratified sand and pebbly sand with red sandy till on the surface in places. This sector contains greater relief than the rest of the moraine with local relief of 130 feet (40 m) or more in places. Several sand pits, which mostly occur about 6 miles (10 km) south and southeast of Bruce Crossing, Mich., show a veneer of red sandy till over-lying as much as 100 feet (30 m) of exposed sand and smaller amounts of gravel which has been partially deformed by overriding ice. These observations indicate that the smooth north-trending ridges at the north edge of this sector are composed of stratified drift that was overridden and shaped by glacial ice. This ice-smoothed topography apparently continues southward and is veneered with various thicknesses of partially collapsed stratified sand and pebbly sand and small amount of red till. Many of the hills may be kames deposited in water ponded south of the retreating ice front. Several high hills that occur east and northeast of Watersmeet, Mich., are probably composed of stratified drift and may be partially collapsed kame deltas, which were deposited in water ponded by high ground to the south.

Qwn -- Chiefly stratified ice-contact, medium-grained slightly pebbly sand; gravel and very sandy pink till occur in much smaller amounts; red sandy till occurs in small areas. Hill and swale topography with numerous enclosed depressions, many of which contain swamps and lakes; many short ridges that appear to be ice-channel fills. Deposited by the Ontonagon lobe except for an undetermined eastern part that was deposited by the Keweenaw Bay lobe

Qwe -- Chiefly gray and brown till, gravelly sand, and sandy gravel; hummocky topography with many swampy enclosed depressions and few lakes. The moraine appears to be a thin veneer of hummocky drift deposited on a hilly topography. The hills are mostly drumlins, similar to those found south of the moraine, and bedrock knolls. The moraine is more readily identifiable on aerial photographs than on topographic maps. It was deposited by the Keweenaw Bay lobe except the part that is west of about long 80° 45′ W. which was deposited by the Ontonagon lobe

Qm

McDonald moraine -- Narrow ridge commonly about 0.3 to 0.6 miles (0.5 to 1 km) wide and 16 ft (5 m) high and composed chiefly of calcareous red sandy till. The ridge is interrupted by two gaps and several kame deltas and ice-channel fills. Deposited by the Ontonagon lobe. Named for McDonald Lake, Gogebic Co., Mich.

Qsj

Saint Johns moraine -- Composition poorly known, brown stoney sandy till observed in one place; forms straight narrow well-defined ridge commonly 0.5 to 1.2 miles (1 to 2 km) wide and 15 to 75 feet (5 to 25 m) high; surface dotted with hillocks and small depressions. Deposited by the Michigamme lobe. Named for Saint Johns Lake, Baraga Co., Mich.

Qsa

Sagola moraine -- Chiefly calcareous red sandy till with lesser amounts of stratified sand and gravel in the southern part, and ice-contact stratified gravel and sand and lesser amounts of calcareous red sandy till in the northern part; a narrow hummocky ridge in the southern part, hill and swale topography with numerous poorly drained depressions and lakes in the northern part. Deposited by the Green Bay lobe. Named for Sagola, Mich.

Qw

Watton moraine -- Chiefly calcareous red clayey till in the southeastern part and calcareous red clayey till, calcareous red sandy till, and sand in the northwestern part; subdued topography with generally well-integrated drainage east of Watton, Mich.; subdued hummocky topography with numerous poorly drained depressions and a few lakes west of Watton. The western part bordering the Sidnaw delta is strongly collapsed. Deposited by the Keweenaw Bay lobe except for the west-trending part north of the Sidnaw delta which was probably deposited by the Ontonagon lobe. The boundary with the Sixmile moraine is approximately located. Named for Watton, Mich.

Qsi

Sixmile moraine -- Mostly sand and partly calcareous red till east of the Sturgeon River; calcareous red clayey till, calcareous red sandy till and sand west of the Sturgeon River. Subdued hill and swale topography with numerous lakes in some areas. Deposited by the Keweenaw Bay lobe. Named for Sixmile Lake, Ontonagon Co., Mich.

Qu

Unnamed moraines -- This unit includes several small, rather indistinct, ridges and hummocky areas that have been segregated out as end moraines. They are identifiable only on topographic maps.

The moraine shown east of the Sagola moraine is composed chiefly of sand, gravel, and calcareous red sandy till. It forms a poorly defined hummocky ridge mostly 0.3 to 1.2 miles (0.5 to 2 km) wide and up to about 50 feet (15 m) high. It is composed partly of collapsed outwash fans. Deposited by the Green Bay lobe.

The small moraine shown northeast of the Saint Johns moraine is a poorly defined hummocky ridge 0.3 to 0.6 miles (0.5 to 1 km) wide and 16 to 65 feet (5 to 20 m) high. Its composition is not known. Deposited by the Michigamme lobe.

The segment of end moraine that occurs north of Bruce Crossing, Mich., is composed of sand, gravel, and calcareous red sandy till. The compositions of the segments that occur just north of Matchwood, Mich., and Topaz, Mich., are not known except that they are veneered with red lacustrine silty clay in places. These three morainic segments were deposited by the Ontonagon lobe probably at the same time as the segment of the Watton moraine north of the Sidnaw delta. A glacial lake that drained westward through the low area in which Lake Gogebic is located was ponded south of the ice front at this time. The end moraine at the southwest extremity of the Iron River basin is composed of red sandy till along the road that crosses the southern part. The till was deposited by ice that moved westward through the Iron River basin. It may be the same age as the Watton moraine. The composition of the end moraine west of Porcupine Peak is not known. It may also be the same age as the Watton moraine. Deposited by the Ontonagon lobe

THIN DRIFT OVER BEDROCK (WISCONSINAN)

Areas where glacial drift is commonly less than 10 feet (3 m) thick and where the topography is essentially that of the bedrock surface slightly modified by the veneer of drift.

Qgn

In northwest part of map -- Chiefly calcareous red till composed of fine sand, silt, and clay with a small percentage of angular clasts of sandstone and greenstone on the Ontonagon Plain, in the Iron River basin, and around and west of the Porcupine Mountains. Hack (1965) presents a more detailed three-fold subdivision of the sediments underlying the Ontonagon Plain. South of about lat 40° 37′ 30" N. the till is also red but has a large component of medium-grained sand. Many areas, particularly south of lat 40° 37′ 30" N. have unmapped ice-contact sand and gravel on the surface which presumably overlies red till. The drift in this unit may be considerably thicker than 10 feet (3 m) in some areas particularly east of the Ontonagon River and in the low area west of Lake Gogebic. Deposited by the Ontonagon lobe.

The Ontonagon Plain and Iron River basin were mapped as "clayey beds of glacial lakes" by Leverett (1929, pl. 1). Except for a few small localities, red till is found at the surface throughout this area. Several meters of lacustrine silty clay were observed where Michigan Highway 38 crosses the Flintsteel River indicating that there was a filling of lacustrine deposits in some low areas after the last glacier had retreated

Qgk

Near Keweenaw Bay -- Chiefly red sandy to very sand till which is essentially pulverized Jacobsville Sandstone. The till, which lies on the Jacobsville Sandstone, is commonly thin, less than 6 feet (2 m) in many places. Deposited by the Keweenaw Bay lobe

Qge

In eastern part of map -- Stoney sandy gray and brown till and gravel and sand. These areas are generally hilly, the hills being mostly bedrock with a thin veneer of drift. Deposited by the Langlade, Keweenaw Bay, and Michigamme lobes

Qgs

In extreme southeast part of map -- Sand, gravel, and red sandy till; in part, streamlined in a west-trending direction. Deposited by the Green Bay lobe

Qgu

Thin drift and unmapped bedrock outcrop -- Area contains an abundance of unmapped bedrock outcrops; the topography is essentially that of the bedrock surface. A thin veneer of gravel and sand and gray and brown till is present, particularly in the low areas. The drift was deposited by the Keweenaw Bay and Michigamme lobes

LINEATED TOPOGRAPHY UNITS (WISCONSINAN)

Qgd

Drumlin topography -- East of the interlobate deposit, chiefly gray and brown sandy stoney till deposited by the Langlade lobe. A typical drumlin is 0.5 to 1 miles (0.8 to 1.5 km) long, 0.3 miles (0.5 km) wide, and 50 feet (15 m) high. Drumlin orientation is shown on the map, most drumlins are oriented S. 30°-40° W. Near Iron River, Mich., till overlies older stratified gravel and sand, which forms the cores of the drumlins. The till there is brown and the stones tend to be well rounded and are probably derived from the older gravel and sand.

West and northwest of the interlobate deposit, the drumlins are composed of red calcareous sandy till and were deposited by the Ontonagon lobe. The drumlins south of the Winegar moraine are mostly about 1 mile (1.5 km) long, 0.3 mile (0.5 km) wide, and 15 to 50 feet (5 to 15 m) high. Those north of the Winegar moraine are 0.3 to 1.5 mile (0.5 to 2.5 km) long, 0.2 to 0.6 mile (0.3 to 1 km) wide, and 15 to 50 feet (5 to 15 m) high. The drumlin orientation is shown on the map.

The drumlin topography is composed of the drumlins and the intervening grooves. The grooves at lower altitudes tend to contain deposits of outwash and ice-contact stratified sand and gravel of which only the larger areas have been separated out into different map units

Qgf

Fluted till -- Chiefly calcareous red till composed of fine sand, silt, and clay; essentially the same as found in the "thin drift over bedrock" unit elsewhere on the Ontonagon Plain and in the Iron River basin. The flutes are straight narrow U-shaped grooves separated by straight round-topped, even-crested ridges. According to Hack (1965), the distance from ridge crest to adjacent ridge crest averages 380 feet (116 m), the height of the ridges averages 10 feet (3 m), and the lengths of the ridges extend up to 3 miles (4.8 km) between White Pine, Mich., and the Cranberry River. These measurements are probably representative for the entire area. The flutes were formed by the Ontonagon lobe

Qgr

Irregular ridge drift -- Chiefly gray and brown stony sandy till and gravel. Stones are mostly graywacke from the underlying Michigamme Formation. The surface is characterized by irregular ridges of widely differeing dimensions, but which are commonly between 0.2 and 0.6 mile (0.25 and 1 km) wide and 0.6 to 2 mile (1 to 3 km) long, and by intervening elongate low areas of similar dimensions. The ridges are mostly less than 15 feet (5 m) high. These ridges do not have the smooth regular

surfaces as found on drumlins and on the ridges between flutes. Their orientation and composition, however, indicate that they were also formed beneath moving glacial ice. Deposited by the Keweenaw Bay lobe

GLACIAL DELTA UNITS (TOPSET AND FORESET PARTS) (WISCONSINAN)

Qd

Sidnaw delta -- Yellowish-gray, medium-grained sand with a surface veneer of pebble gravel in the northern part. Deposited in a glacial lake which had shoreline at present uplifted altitude of about 1400 feet (427 m) and which drained westward through the low area in which Lake Gogebic is located (fig. 3F). The flat topset surface becomes progressively more collapsed eastward and grades topographically into the Watton moraine. Sediment derived from the Keweenaw Bay lobe

Qdr

Rousseau delta -- Yellowish-gray, medium-grained sand deposited in a glacial lake, which had shoreline at present uplifted altitude of 1200 feet (366 m) and which must have drained through the Copper Range and then westward along the front of the Ontonagon lobe (fig. 3G). Sand beds foreset west were observed in a sand pit just north of Michigan Highway 28 near the west edge of the delta. Topset surface passes abruptly eastward into higher ground of the Sixmile moraine along most of the eastern edge. Sediment derived from the Keweenaw Bay lobe

GLACIAL LAKE DEPOSITS (MOSTLY BOTTOMSET BEDS) (WISCONSINAN)

Ql

Lacustrine red silt and clay -- Calcareous red clayey silts and silty clay; faintly laminated in places but commonly not laminated; contains abundant small white calcareous concretions, abundant sand grains, and sparse pebbles. Thickness is extremely variable ranging from a mere film along the southern edges to at least 250 feet (75 m) exposed where U.S. Highway 45 crosses the Ontonagon River. These lake deposits are not all the same age. The deposits in the southern part of the mapped area reach up to an altitude of at least 1350 feet (412 m); the deposits between that altitude and 1200 feet (366 m) must have been deposited when the Sidnaw delta was built. The deposits below 1200 feet (365 m) were mostly deposited when the Rousseau delta was built. The dashed line locates the approximate boundary between these younger and older deposits.

It seems probable that the reason large thicknesses of lake deposits do not extend through the passes in the Copper Range and onto the Ontonagon Plain is because glacial ice of the last advance of the Ontonagon lobe occupied the Ontonagon Plain when the lake sediments were deposited just south of the Copper Range

Qls

Lacustrine sand -- Area west of the Sidnaw delta is underlain by yellowish-gray, medium-grained sand; the part above the dashed line deposited when the Sidnaw delta was built, the part below probably mostly when the Rousseau delta was built. Several pits which expose about 15 feet (5 m) of sand and minor gravel occur in the area mapped west of Ontonagon, Mich. These sediments are probably deltaic and apparently were deposited by the Ontonagon River when the glacial lake occupying the Lake Superior basin had an altitude of about 645 feet (197 m) during the waning stages of the last advance of the Ontonagon lobe

Qlk

Lake deposits near Keweenaw Bay -- Lake sediments deposited in lakes ponded in front of the Keweenaw Bay lobe. Yellowish-gray, medium-grained sand in the area south of the Sixmile moraine. Surface sand has been blown into dunes; this sediment was derived from the Keweenaw Bay lobe when the Sixmile moraine was being built and deposited in a glacial lake that stood to the south and drained through the large meltwater channel located a few kilometers northwest of Sidnaw, Mich. (fig. 3G). Sediment in the deeply gullied area north of the Sixmile moraine is primarily medium-grained sand but also includes pebbly sand and minor till. Most of this sediment was probably deposited when the Keweenaw Bay lobe retreated from the Watton moraine and was probably overridden by the ice that built the Sixmile moraine (fig. 5A). The lake deposits, which overlie red till in many places in the lowlands north of the gullied area, are medium- and fine-grained, yellowish-gray sand and red calcareous clay deposited when the ice retreated from the Sixmile moraine (fig. 3H)

ICE-CONTACT STRATIFIED DRIFT (WISCONSINAN)

Qb

Interlobate deposit -- Mainly strongly collapsed glaciofluvial gravelly sand and medium-grained sand that was deposited over dead glacial ice; the surface is composed of steep-sided hills and numerous enclosed depressions, which commonly contain swamps and lakes. Probably an interlobate deposit formed between the Langlade and Ontonagon lobes; the front of the Langlade lobe probably remained about stationary as the front of the Ontonagon lobe slowly retreated

Qi

Hill and swale topography -- West of the interlobate deposit, the sediment is mainly slightly pebbly medium-grained sand with some small areas of pebble gravel and cobbly pebble gravel. This area contains numerous lake-filled kettles and swampy depressions interspersed with hill and swale topography containing many ridges oriented about N. 70° W. The sediments were deposited over, under, and around dead glacial ice by streams running off the continuously retreating front of the Ontonagon lobe which was oriented about N. 70° W. The drumlins near the southwest corner of the map are partially buried by this sediment.

East of the interlobate deposit, the sediment is mostly gravelly sand and gravel which occur mainly in poorly preserved kame terraces, ice-channel fills, and small pitted outwash plains. Mostly deposited there by streams coming off the Langlade lobe.

In the areas west and northwest of Chief Lake, which is located 4 miles (6.5 km) northwest of Witch Lake, Mich., the sediment is mostly gravel with lesser amounts of sand and some gray and brown till. The topography is rough with steep-sided hills and swales and small pitted outwash plains. This sediment, plus that in areas immediately to the south, which lie to the east of the line locating the westward extent of the Green Bay lobe, were presumably deposited by streams coming off that lobe.

In the area south of the Michigamme Reservoir, the sediment is mostly medium-grained sand, which is blown into dunes in places east of the Crystal Falls moraine

Qic

Ice channel fills and kame deltas -- Mostly yellowish-gray medium-grained sand with much smaller amounts of rounded pebble gravel; the surface is commonly veneered with a layer of gravel, including boulders, or, in places, till. Several of the equidimensional forms shown on the map are probably glacial deltas built into glacial lakes in or in front of the ice

Qk

Kames -- Mostly stratified sand and gravel. These hills are classified as kames and probably were deposited in openings in the ice as the Ontonagon lobe retreated from the Winegar moraine. However, their internal structure is poorly known and their origin is somewhat in doubt

Eskers -- Mostly rounded pebble and cobble gravel with minor amounts of interstratified sand

OTHER DEPOSITS OF STRATIFIED DRIFT (WISCONSINAN)

Qim — Ice-marginal, stratified drift -- Mostly yellowish-gray, medium-grained sand. Apparently deposited along the margin of the Keweenaw Bay lobe. Probably mostly fluvial but may be partly lacustrine

Qo — Outwash plain -- Chiefly yellowish-gray, medium-grained glaciofluvial sand with a thin veneer of pebble gravel in places; the flat surfaces are variably pitted with small kettles. In the southwestern part of the map, several elongate plains, generally having northwest orientations transverse to the local drumlin direction, were probably deposited parallel to the retreating front of the Ontonagon lobe. Some of these plains may have been deposited in glacial lakes

Qv — Valley train -- Mostly rounded pebble gravel and lesser amounts of sand and cobble gravel. Only the most prominent and easily recognized valley trains are mapped

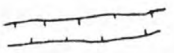
Qmc — Meltwater-channel deposits -- Probably mostly medium-grained sand; deposits not observed in the field

BEDROCK

Areas of exposed bedrock or areas in which there are numerous bedrock exposures. Compiled from various sources

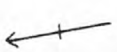
EXPLANATION OF SYMBOLS

Contact



Sides of meltwater channel

Directions of the long axes of drumlins, flutes, or irregular ridges formed by overriding ice-symbol is placed on an individual landform but commonly is representative of the orientation of several in the vicinity of the symbol



Glacial striae (from Martin, 1957; Hack, 1965)

▲ Z — Radiocarbon date locality; 1 = W-964, 2 = W-1540 and W-1541

Approximate limit of the advance of the Green Bay lobe which built the Crystal Falls moraine
Approximate limit of the latest advance of the Ontonagon lobe which occurred about 10,200 years B.P.

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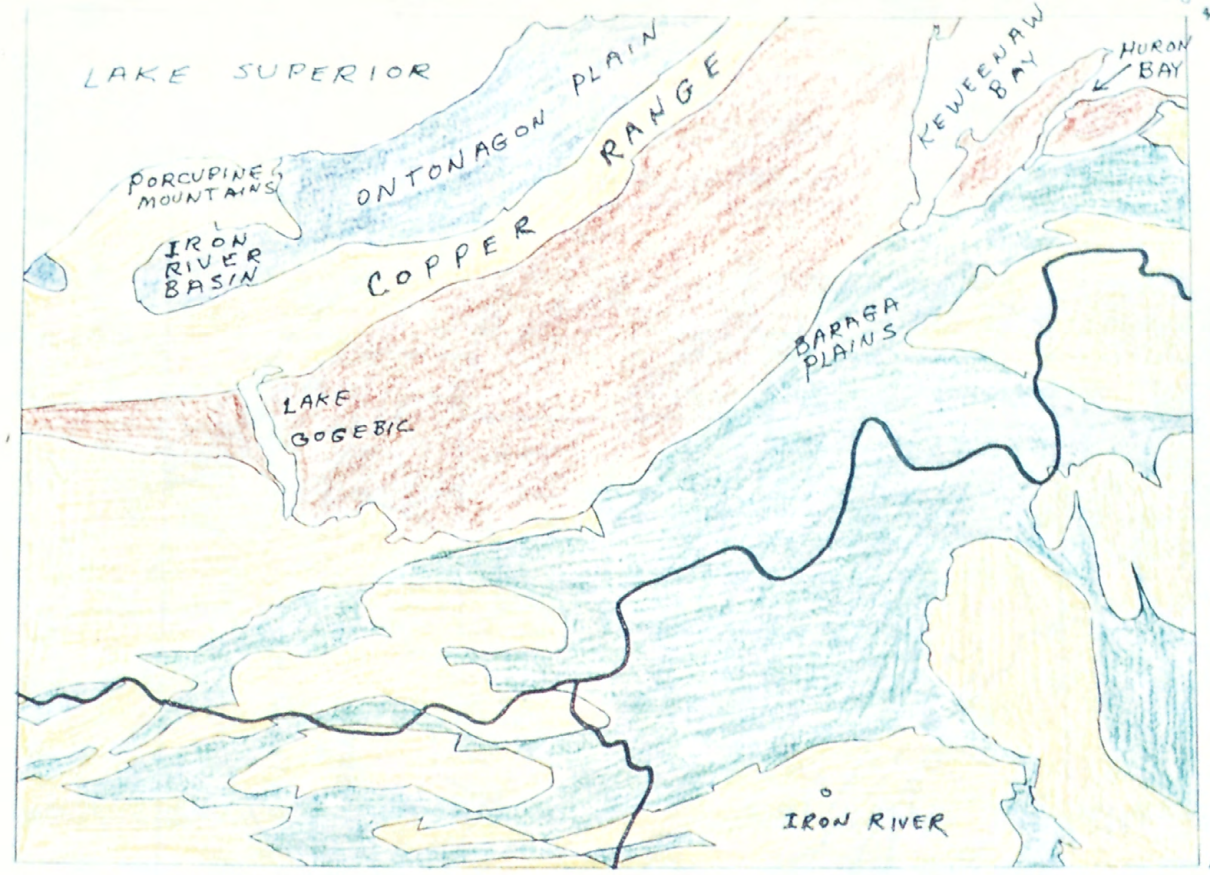


EXPLANATION

0 10 20 Kilometers

Jacobsville Sandstone	Freda Sandstone	Michigamme Formation	other formations
Red,, brown, and white quartzose sandstone; minor siltstone, shale, and conglomerate	Mostly reddish-brown alternating layers of medium- to fine-grained sandstone, siltstone, and micaceous shale	Mostly gray metamorphosed graywacke, gray and black slate dominant just southeast of Keweenaw huron Bays	Mostly basalt in northwest part; granitic rocks, migmatite, amphibolite, iron formation, volcanic rocks, and sedimentary rocks in rest of quadrangle

Major drainage divides

Figure 1--Map of the Iron River 1° X 2° quadrangle showing the generalized bedrock geology, the locations of several major geographic features, and major drainage divides. The surface water drains northward to Lake Superior north of the west-trending drainage divide, southwestward to the Mississippi River west of the north-trending divide, and southeastward to Green Bay in the southeastern part of the quadrangle. The names Iron River Basin and Ontonagon Plain are from Hack (1965). The geologic descriptions and contacts are modified from W.C. Cannon (written commun., 1982).

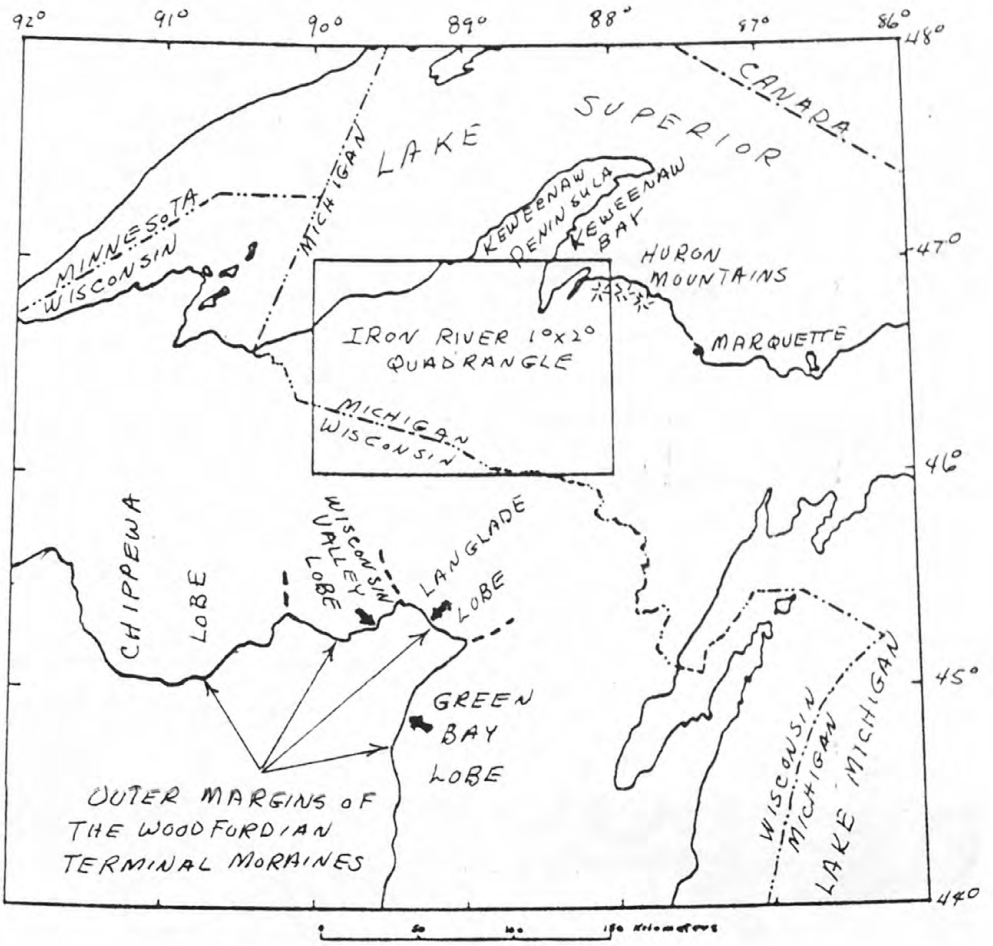
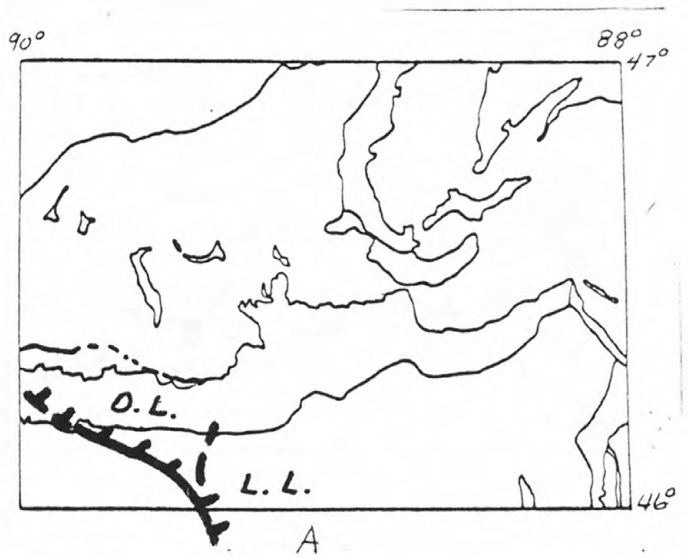


Figure 2--Map showing the location of the Iron River 1 X 2 quadrangle, the location of the outer margins of the Woodfordian terminal moraines of northern Wisconsin, and the names of the glacier lobes that deposited the moraines. The margins of the terminal moraines are taken from Hadley and Pelham (1976). The dashed lines separating the lobes are approximate generalized boundaries. Mickelson, Nelson, and Stewart (1974) have reported a complex history of movement of the lobes that occurred during the deposition of the terminal moraines.



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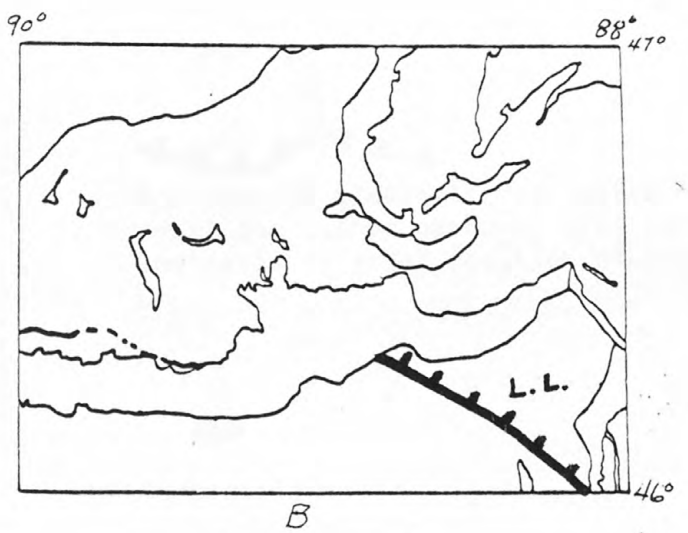

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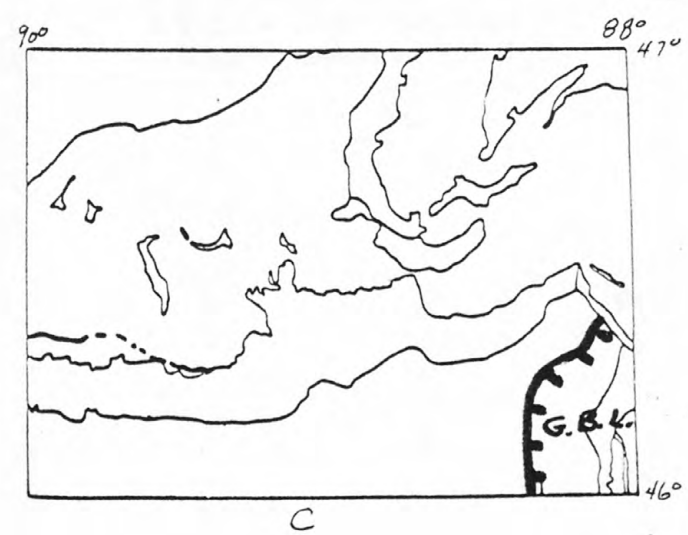

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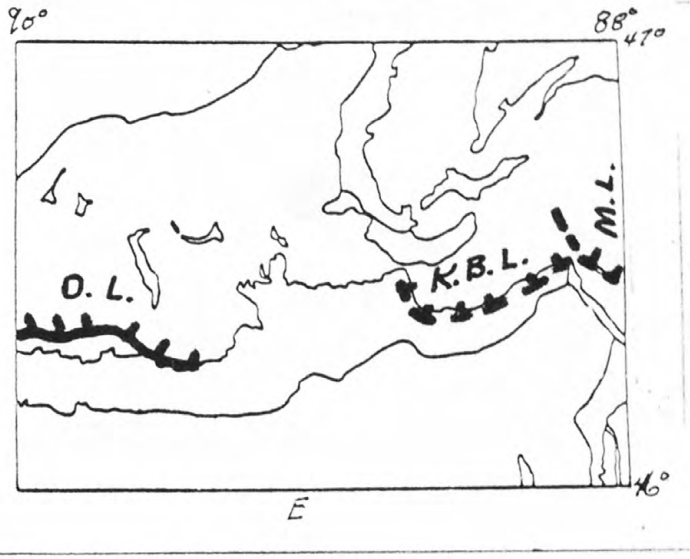

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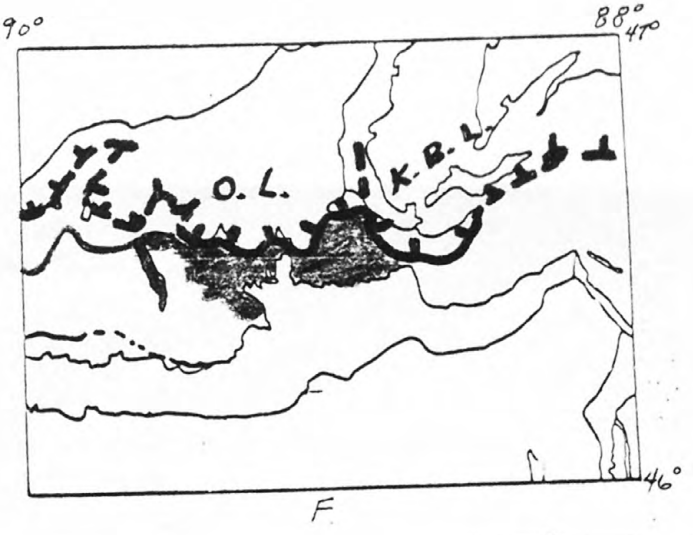

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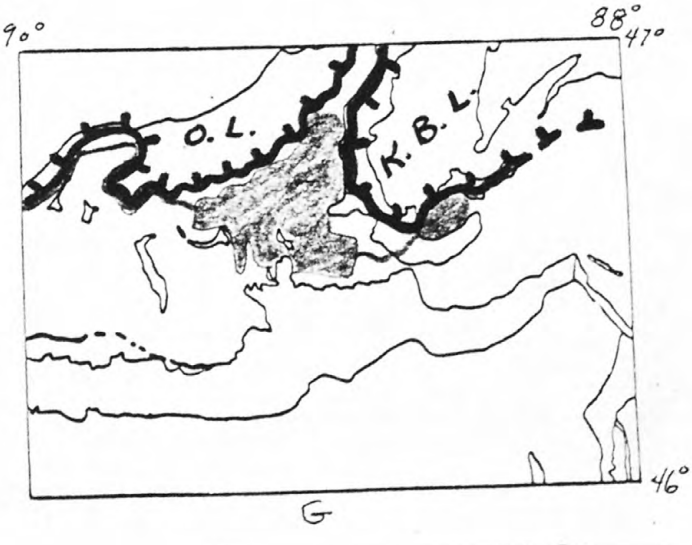

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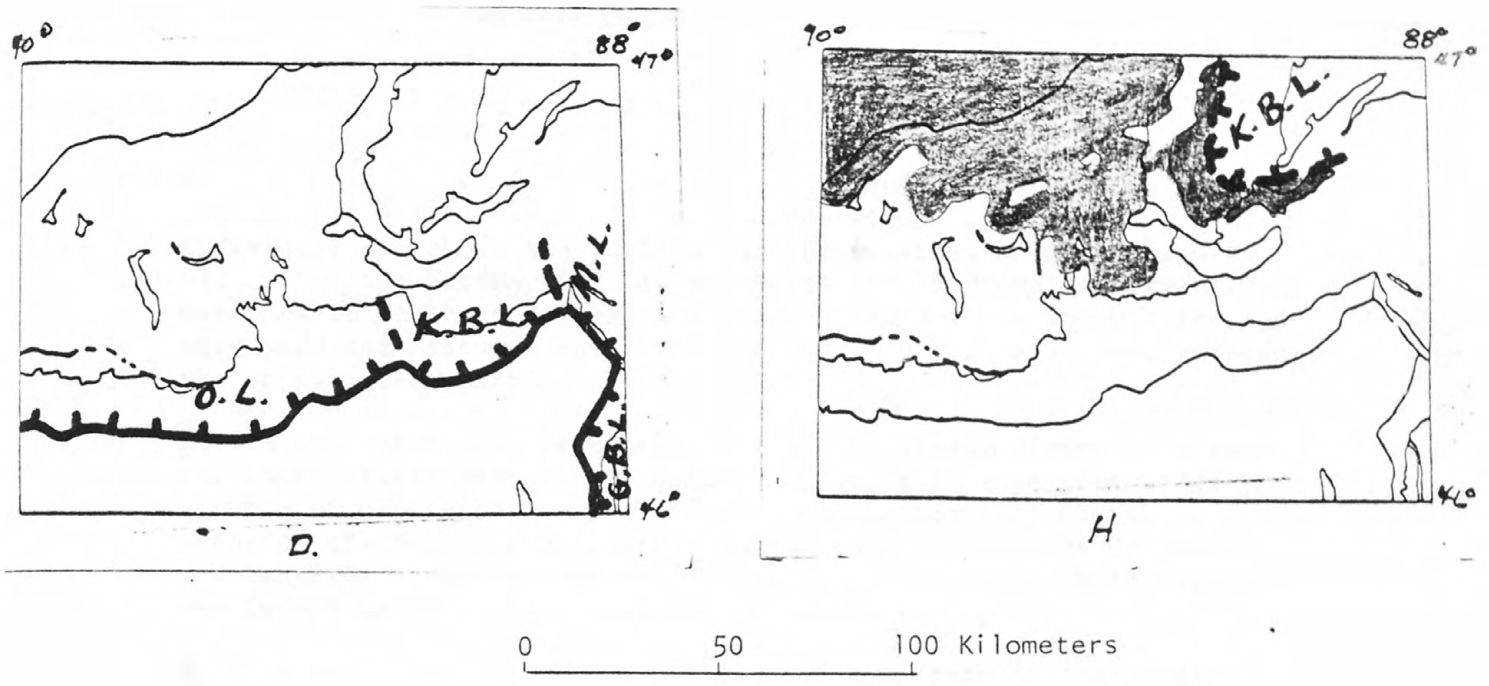
Figure 3.



EXPLANATION

Position of glacier front--solid hachured line indicates known or probable position; dashed hachured line indicates inferred position; dashed line indicates inferred position of interlobate suture

Glacial lake

O.L. = Ontonagon lobe
L.L. = Langlade lobe
M.L. = Michigamme lobe
G.B.L. = Green Bay lobe
K.B.L. = Keweenaw Bay lobe

Figure 3

FIGURE 3.--A series of maps of the Iron River quadrangle showing the sequence of glacial events that occurred within its borders (each individual map shows the outlines of the moraines shown on figure 4). After the Woodfordian ice had built the Woodfordian terminal moraines in northern Wisconsin (fig. 2), the various lobes retreated northward and eastward until the front of the Ontonagon lobe entered the southwestern part of the quadrangle.

A, The Ontonagon lobe retreated in a northeasterly direction across the southwestern part of the quadrangle where it deposited large amounts of glaciofluvial sediment. The map shows a probable position of the ice fronts when the juncture between the Ontonagon and Langlade lobes entered the quadrangle. The interlobate deposit was formed as the lobes continued to retreat.

B, This map shows a probable position of the front of the Langlade lobe after it had retreated well into the quadrangle. It then retreated northeastward to beyond the position of the Saint Johns moraine.

C, The Green Bay lobe advanced to the position shown and built the Crystal Falls moraine. It then retreated to some position eastward of the front of the Sagola moraine leaving much collapsed stratified drift east of the line of maximum extent shown on the map.

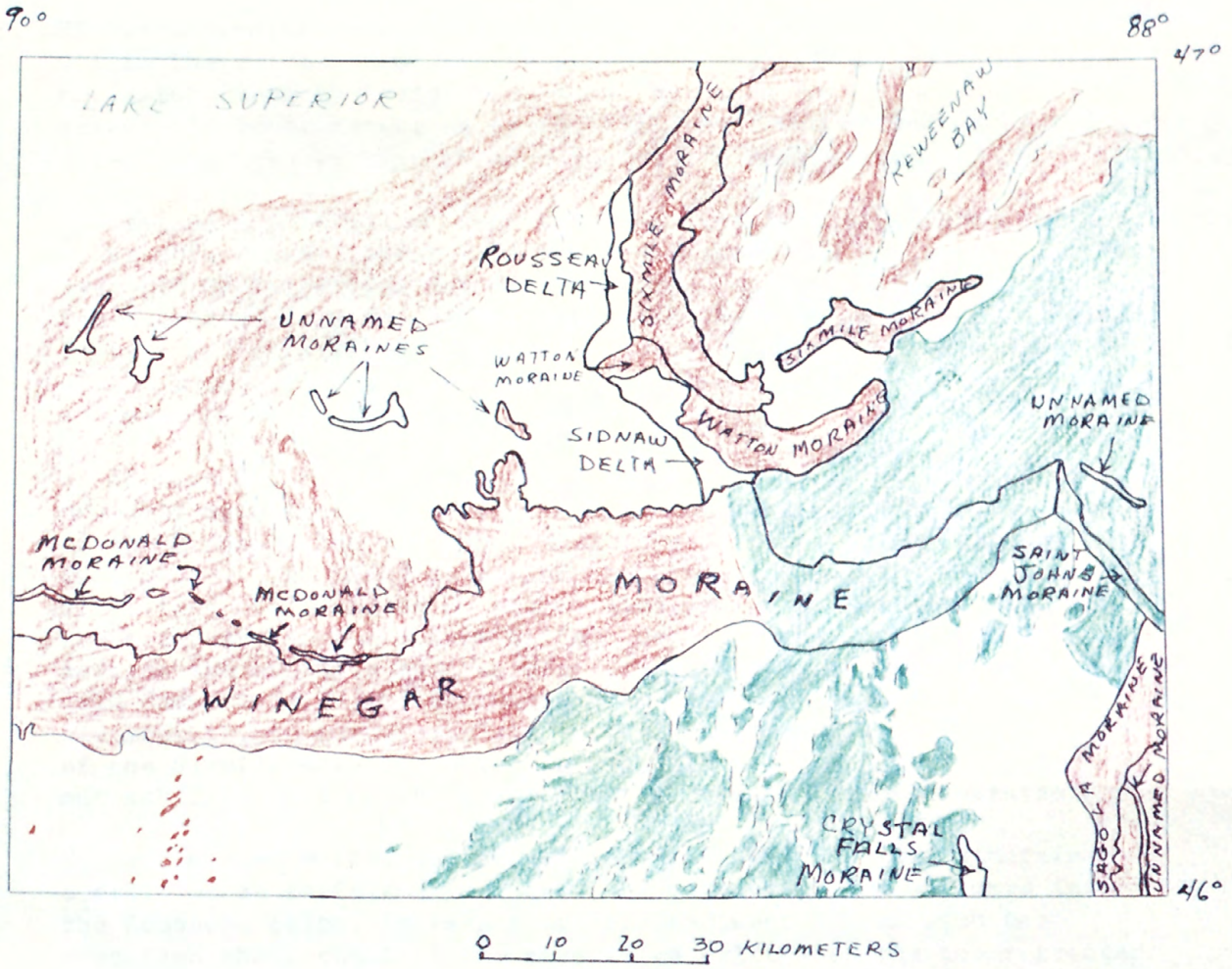
D, All lobes readvanced, the Langlade lobe now is represented by the Keweenaw Bay and Michigamme lobes. The Winegar moraine was built by the Ontonagon and Keweenaw Bay lobes, the Saint Johns moraine by the Michigamme lobe, and the Sagola moraine by the Green Bay lobe. The moraines deposited by the various lobes may not be exactly contemporaneous but probably are about so.

E, This map shows the positions of the Green Bay and Michigamme lobes when the small unnamed moraines that occur east of the Sagola moraine and northeast of the Saint Johns moraine were built. Whether they record a readvance or a halt in the retreat is uncertain; they are probably about contemporaneous. After deposition of these small moraines, the Green Bay and Michigamme lobes retreated out of the quadrangle and did not reenter. The positions of the Keweenaw Bay and Ontonagon lobes are not certain. The McDonald moraine, however, may have been deposited at this time by the Ontonagon lobe. The Keweenaw Bay lobe must have retreated far enough to allow red clay to be deposited in a proglacial lake in the vicinity of Watton, Mich.

F, The Keweenaw Bay lobe readvanced and built the Watton moraine. The Ontonagon lobe probably occupied a position at this time about as shown and built the northernmost, west-trending, segment of the Watton moraine and the moraines mapped northeast of Bruce Crossing, Mich., and north of Matchwood, Mich. The unnamed moraines mapped west and southeast of Porcupine Peak may have been built by the Ontonagon lobe at this time. A glacial lake, which corresponds approximately to Lake Ontonagon of Leverett (1929), was dammed south of the Ontonagon lobe and west of the Keweenaw Bay lobe. The Sidnaw delta was built into this lake by sediment from the Keweenaw Bay lobe. The lake drained westward through the low area in which Lake Gogebic is located. The drainage route shown is similar to that of Leverett (1929) but is only one of several possible routes depending on the actual location of the front of the Ontonagon lobe. The Ontonagon lobe apparently then retreated northward beyond the shores of the present Lake Superior. The Keweenaw Bay lobe retreated depositing sand, pebbly sand, and minor till north of the Watton moraine in the area north and west of the Baraga Plains.

G, The Ontonagon and Keweenaw Bay lobes readvanced; the Keweenaw Bay lobe overrode part of the deposits described above and built the Sixmile moraine (see fig. 5A, section AA′). While the moraine was being built, the Rousseau delta was constructed in a glacial lake that was ponded to the west, south of the Copper Range. Large volumes of lacustrine silt and clay were deposited in the lake west of the Rousseau delta. This lake can be considered an early stage of Lake Duluth and must have drained through a low pass in the Copper Range and then westward along the edge of the Ontonagon lobe to the St. Croix valley.

H, The Keweenaw Bay and Ontonagon lobes retreated and glacial Lake Duluth occupied the area below an altitude of about 1200 ft (366 m) and drained westward until the ice retreated far enough to uncover lower outlets to the east.



EXPLANATION

Area where red till occurs

Area where gray and brown tills occur

Figure 4--Map of the Iron River 1° X 2° quadrangle showing names and locations of end moraines and deltas and the areas where the red till and the gray and brown tills occur. The contact between the red till on the west and the gray and brown tills on the east within the Winegar moraine was not located in the field and is arbitrarily located in what seems a likely place. The uncolored land areas are essentially free of till at the surface. The name Winegar moraine is from Thwaites (1929); the other names are new.

FIGURE 5.--Schematic cross sections showing inferred relationships within the drift. Most of the subsurface relationships shown are not established by field observation but seem to be the most reasonable interpretations of the field evidence collected to date. Thicknesses of glacial deposits are exaggerated.

A, Section A-A'--Till of the Watton moraine lies on bedrock and older thin drift. Other till the same age as the Watton moraine is overlain by lacustrine deposits and other outwash deposited as the ice retreated from the Watton moraine. These sediments are overlain by till and stratified drift of the Sixmile moraine. Lake deposits of the Baraga Plains were deposited in front of the Sixmile moraine and overlie older deposits.

B, Section B-B'--Either a bedrock ridge or a ridge of older drift probably underlies the part of the Watton moraine that stands east of the Sidnaw delta and acounts for the location of the moraine in this place. The older drift and bedrock are overlain by till and stratified drift of the Watton moraine, which grades westward into the sediments of the Sidnaw delta. Deposits the age of the Watton moraine are overlain by lake deposits and other outwash that were laid down when the ice retreated from the Watton moraine. This sediment is, in turn, overlain by till and stratified drift the age of the Sixmile moraine, which is overlain by lake deposits and outwash laid down as the ice retreated from the Sixmile moraine.

C, Section C-C'--Till and stratified drift of the Sixmile moraine overlie older drift and bedrock. The moraine grades westward into the Rousseau delta. A veneer of lake sediment and outwash was deposited above the till and stratified drift when the ice retreated from the Sixmile moraine.

D, Section D-D'--Ice-contact stratified drift, till, outwash, and probably lake beds overlain by the stratified drift and till of the Winegar moraine. South of the moraine, till older than the Winegar moraine lies on the surface of the drumlins, which are cored in some places with stratified drift. North of the Winegar moraine, till the same age as the moraine overlies stratified drift in the streamlined forms that occur there. The till is in turn overlain by lacustrine silt and clay.

E, Section E-E'--Stratified drift overlain by the till and stratified drift of the Winegar moraine. Till the same age as the Winegar moraine lies on bedrock to the north. This till is overlain by an ice-channel fill deposited when the ice that built the Winegar moraine retreated. Older drifts may be present beneath those shown.

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