VALDERAN GLACIATION IN WESTERN UPPER MICHIGAN

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ABSTRACT

During part of each of the summers of 1966-68, field reconnaissance in western Upper Michigan revealed a complex deployment of ice during late Woodfordian and Valderan times. Various movement indicators, such as striae, drumlins, drumloid features, and fluted forms, and ice-margin features, such as end moraines and outwash plains, are more important than color, texture, and composition of drift sheets in determining former deployment of the ice. They reveal several distinct lobes between which relative age relationships may be seen. A probable Valderan boundary was mapped in the Huron Mountains northwest of Marquette, and thence, with breaks westward and southward into Baraga County. It is believed also to extend northward to the base of the Keweenaw Peninsula and across it south of Houghton. Several late pulses of the Valderan ice seem to have occurred, in part from centers controlled by topography and local precipitation. Different interpretations are possible within the framework of data on hand.

INTRODUCTION

In areas of older drift in the Upper Mississippi Valley region deployment of ice generally has been reconstructed by correlating tills of distinctive color, texture, and lithology in stratified sequences in scattered sections. Original morphological features of the drifts commonly have been so modified by erosion that they are of little help; striae are scarce. Hence, tracing of drift sheets by direction indicators is not always possible or practicable. In those areas of strong bedrock relief in northern Wisconsin and Upper Michigan, uniformly stratified drift sheets are rare or not exposed. The former glaciers did not have opportunity everywhere to homogenize thoroughly their subsequent deposits into distinctive drifts of different color, texture, and lithology. Hence, those characteristics in northern Wisconsin and Upper Michigan are less important than are the widespread, fresh, bedrock striae and morphological features which indicate directly the former deployment of the ice.

Striae that have been exposed since deglaciation are much weathered and mostly destroyed. However, only one or two feet of drift is sufficient to have protected most striae from destruction. Digging of shallow pits generally reveals them adjacent to weathered outcrops.

Utilizing end moraines and outwash aprons as marginal features and bedrock striae and various drumlins, drumlinoid features, and fluted forms in unconsolidated materials as direction indicators, Black (1966) traced the boundary of the Valderan glacial drift from the type locality in east Wisconsin northward to the vicinity of Marquette, Upper Michigan. There the boundary was lost. During a small part of each of the summers of 1966-68, Black carried on reconnaissance in western Upper Michigan in an attempt to trace drift borders and work out the former deployment of the ice. Some tentative results are summarized on Figure 1. Aerial photographic mosaics and topographic maps both on the scale of one mile to the inch were used as guides and a base. The large scale individual photographs which went into the mosaics were not available to the writer for detailed study. Less than half the total main road network was covered; traverses off the roads were made only in a few areas.

A probable Valderan boundary was mapped in the Huron Mountains northwest of Marquette, and thence, with breaks westward and southward into Baraga County (not named on Fig. 1). The boundary there is believed to swing westward and northward to the south-center of Keweenaw Peninsula, thence northwesterly across the Peninsula, in the vicinity of Donken (D on Fig. 1), about 16 miles southwest of Houghton. Late Valderan ice is thought to have hung on last in the Porcupine and Huron Mountains and in the Baraga Plains (P, H, and B respectively on Fig. 1).

These reconnaissance studies have led to a markedly different interpretation of the deployment of late Wisconsinan ice in the Upper Peninsula from those of Leverett (1929) or Martin (1957). They suggest a complex deployment of ice during both Late Woodfordian and Valderan times. However, the boundaries still need further refinement. The ice in many places terminated in lakes or rugged hills and did not leave prominent marginal features. Different interpretations also are possible with the data at hand. The correlation of major lobes with Late Woodfordian and Valderan times also needs confirmation by other methods of study, such as radiocarbon dating of bog deposits laid down on the various drifts. Thus, this study is considered only the primary reconnaissance to define the major lobation of the ice and to permit selection of representative areas for more detailed study. In this note only a summation of the deployment of the ice is attempted. Results of other studies, such as the characteristics of the drift, must await further laboratory investigations.

LOBATION OF ICE IN WESTERN UPPER MICHIGAN

Lobation of ice in western Upper Michigan has been determined largely from the use of direction indicators - the bedrock striae and morphometric features like drumlins, drumlinoid forms, and fluted forms in drift - and end moraines and associated outwash. Till fabrics were not determined unless good exposures were present and pebble alignment easily seen megascopically without detailed studies. Very few such sites were found, and they were used only to confirm the morphologic determination.

The bedrock striae where found on hills or ridge tops are considered indicative of regional movements; those on hill sides or in valley bottoms are suspected of showing local control by the topography, and generally are excluded from Figure 1. "Crag and tail" features and micro-plucking permit a single direction to be selected in most locations.

Bedrock striae do not necessarily indicate the direction of the last ice that might have covered the area. It is necessary to compare the direction of such striae with direction indicators in the overlying unconsolidated deposits. Drumlins, drumlinoid forms, and fluted forms are especially indicative of the last direction of movement. Such forms are seemingly in part molded or squeezed into shape, in part depositional, and in part erosional. Their genesis is beyond the scope of this note, but all seemingly indicate the direction of the last ice advance immediately prior to still stand and destruction. The marked parallelism of topographic forms lends itself easily to distinguishing two directions at 180 degrees to each other; many forms also display stoss-lee ends which limit the selection of ice movement to only one direction.

In a number of instances more than one set of striae are present and permit younger and older directions to be selected by cross-cutting relationships. In other instances, an older set of bedrock striae differ significantly from younger direction indicators in the overlying drift. In still other restricted locations where multiple sets of bedrock striae are found, the direction indicators in the overlying drift can be correlated precisely with the younger set of bedrock striae. Hence, age relationsips in a relative sense may be established between lobes where overlap has occurred.

On Figure 1 bedrock striae are distinguished from direction indicators as shown by morphology of the surface drift. These clearly demonstrate a lobation to the ice around which borders can be drawn as indicated. In perhaps one-fifth of the length of the borders shown, end moraines and local outwash plains confirm the validity of the lobation inferred, the position of the border, and also the relative age relationships between lobes. As the ice in many places terminated in lakes or in rugged hills, end moraines are lacking or are so weak as to be overlooked in the reconnaissance studies. In some intervals of the border, features interpreted as end moraines lie athwart an unbroken assemblage of parallel striae and direction indicators in drift. Thus, the borders shown are only in places located fairly precisely for the scale of the sketch. In other places they are inferred only and may be misplaced considerable distance.

For convenience, individual lobes may be designated informally as 1, Escanaba, 2. Marquette, 3. Huron Mountain, 4. Iron River, 5. Keweenaw, and 6. Lake Gogebic. These are not named on Figure 1. The Escanaba lobe centers around the town of Escanaba on Green Bay (below U. Michigan on Fig. 1). The direction indicators show ice radiated southeast (across Lake Michigan), south, southwest, west, and northwest (not all the lobe is shown on Figure 1; see Black, 1966, for more coverage to the south). A major recessional moraine and outwash are also shown. The Marquette lobe is north of the Escanaba lobe and southeast of Marquette (M on Fig. 1) on Lake Superior. This lobe is separated from the Escanaba lobe only by a narrow, discontinuous end moraine and local outwash. Direction indicators are mostly parallel across the moraine.

In the Huron Mountain lobe (H on Fig. 1) northwest of Marquette, striae are southwesterly and parallel to those in the Iron River lobe (northeast of Iron River, IR on Fig. 1). The boundary between is based on voluminous ice-contact features and outwash at disjunct intervals along the boundary shown. The Huron Mountain lobe is arbitrarily distinguished from the Marquette lobe in the general vicinity of Marquette, but no boundary between them has been recognized. No continuous drift sheets or marginal features can be traced through. Furthermore, the Huron Mountain lobe is not separated by marginal features from the Keweenaw lobe, although drift of similar color, texture, and megascopic composition carries through.

The axis of the Keweenaw lobe lies on Keweenaw Bay, and the last ice moved from a center (B on Fig. 1) southwest of L'Anse to the southeast, south, southwest, west, and northwest. Ice crossed Keweenaw Peninsula generally from east to west. A double border is shown southwest of the Huron Mountains, against the Iron River lobe. The southerly one crosses outwash in the Yellow Dog Plains where many small frontal features exist. The oldest front is not identified.

Ice in the Lake Gogebic lobe, in the western part of the peninsula, moved generally southerly. The boundary between it and the Iron River lobe is marked by end moraine and outwash. The boundary between the Lake Gogebic lobe and ice to the south and west in Wisconsin is not. The west-trending border through Watersmeet (not on Fig. 1) disappears westward.

These lobations of ice in western Upper Michigan are used only for convenience in describing the deployment of the ice and for establishing their relative age relationships to each other. They are collectively part of the Green Bay and Chippewa lobes of Wisconsin. A Langlade and other minor lobes have been named there.

AGE OF THE LOBES

Relative ages of several lobes and adjoining lobes are clear. Overlap areas retain initial striae on which younger striae and morphological direction indicators have been superposed. Confirmation by end moraines and outwash is possible in a number of places. Where boundaries between lobes have dissimilar striae and morpholgic direction indicators, end morainal features and outwash are relatively common. Where striae directions between lobes are conformable, generally only minor moraines and little outwash are seen.

The margin of the Escanaba lobe, as defined by the outer moraine fronting on the Iron River lobe, is Valderan in age by direct tracing from the type locality in east Wisconsin (Black, 1966). Striae and morphological direction indicators of the Iron River lobe can be traced uninterruptedly southwestward into Wisconsin to the prominent moraine near Antigo. They are there part of the Langlade lobe of Cary or Late Woodfordian age. The area of the Iron River lobe in Upper Michigan is considered the same age.

The relative age relationship of the Escanaba lobe to the Iron River lobe in Upper Michigan supports the finding from Wisconsin. The southwesterly striae of the Iron River lobe (1 in northern part of the Escanaba lobe on Fig. 1) clearly are cut by younger northwesterly striae (2 at the same locality on Fig. 1) in the outer fringe of the Escanaba lobe. (More than one locality of such criss-crossing striae were found, but all could not be put on Fig. 1). Morphological direction indicators in the outer fringe of the Escanaba lobe fronting on the Iron River lobe also parallel the younger set of striae of the Escanaba lobe. An end moraine and outwash from the Escanaba lobe cover deposits of the Iron River lobe and confirm the relative age relationship.

A similar relationship is demonstrated by the two sets of striae in the southeastern part of the Keweenaw lobe where it fronts on the Iron River lobe. The southwesterly striae (1 in the southeastern fringe of the Keweenaw lobe on Fig. 1) parallel those of the Iron River lobe and are clearly older and cut by southeasterly striae (2 at the same locality on Fig. 1) parallel to both striae and morphological direction indicators of the drift of the Keweenaw lobe. A similar age relationship obtains in the southeastern part of the Lake Gogebic lobe, where it fronts on the Iron River lobe.

The Keweenaw lobe shows by its end moraine and outwash that it is younger than the Lake Gobebic lobe which is also, in part at least, younger than the Iron River lobe. Hence, it is not possible to conclude from the relative age relationships that the Keweenaw lobe is the same age as the Escanaba lobe merely because they bear the same relative relationship to the Iron River lobe. It is necessary to find other evidence. This has not been done directly from the study of the deployment of the ice alone. Other characteristics must be used to provide a preferred interpretation.

Distinction of the Marquette lobe from the Escanaba lobe is based on a minor end moraine and very little outwash along part of the boundary between them. Direction indicators in the two lobes are mostly parallel.

Nonetheless, the outwash clearly shows the Marquette lobe is younger than the main recessional moraine of the Escanaba lobe. It should be late Valderan in age.

The Huron Mountain lobe with its direction indicators also parallel to those of the Iron River lobe is distinguished by major ice-contact and outwash features in the Yellow Dog Plains and by much smaller but similar occurrences southeastward to Marquette. It is thus younger than the Iron River lobe and the interval of time between must be considerably longer than the interval between the Marquette lobe and the Escanaba lobe. The Huron Mountain lobe is considered Valderan in age. Unfortunately, its border has not been traced through unequivocably from the Escanaba lobe in the Marquette area. Nor has the relationship of the Huron Mountain lobe to the Marquette lobe been established directly by any deposits or features between them. The high relief of the Ishpeming-Marquette region has left only small patches of drift and outwash. They may represent retreatal phases rather than the outermost or oldest margins of the lobes. Reworking by ice marginal lakes has buried or modified many deposits also so their correlation is difficult. Thus, the correlation of the Huron Mountain front at the Yellow Dog Plains with Valderan time is based in part on morphometry, degree of weathering, and volume of material in the ice-contact features and outwash fronting on the Iron River lobe and in part on the lack of any other place to put the Valderan boundary.

The ice-contact relationship with the outwash and topography has been shown by Segerstrom (1964). Probably not all deposits can even be related to Valderan time. Late Woodfordian time may also be represented in the deposits. Minor moraines also have been built on the massive outwash. They and minor features in the Huron Mountains suggest that ice may have hung on in local alpine glaciers or a local center until the very close of the Valders.

If the correlation of the Huron Mountain lobe with the Valderan is correct, then the Keweenaw lobe with which it merges is also Valderan. No end moraine or outwash separate them, and till of similar color, texture, and composition megascopically carry through.

The timing of the Lake Gogebic lobe, which along its east border is distinctly older than the Keweenaw lobe but also younger than the Iron River lobe, must then in its southeastern part at least be placed in latest Woodfordian time. However, east and southeast of the Porcupine Mountains (P on Fig. 1) much younger deposits have been described by Hack (1965). He describes briefly two tills with intervening lacustrine deposits and other more patchy lacustrine deposits on top of the younger till. Wood from the upper till exposed in the side of a kettle was dated as 10,230 ± 280 years B.P.; wood and gyttja from the base of the kettle deposit 5 feet thick on top of the till were dated as 9,600 ± 350 and 9,500 ± 350 B.P. respectively. Hack concluded that the upper till represented a late readvance of the Valderan ice and that the younger dates immediately postdated the retreat of Glacial Lake Duluth from the area. A date of 10,230 ± 500 years B.P. also was obtained on sample No. W.1414 of wood from red clayey till at a depth of 13.5 feet, southwest of the Porcupine Mountains. All these areas were under Glacial Lake Duluth. If these correlations are true, it is obvious that the Lake Gogebic lobe is either of multiple age or the writer's interpretation of the age relationship with the Keweenaw lobe is incorrect. However, Broecker, Kulp, and Tucek (1956) mention that their sample No. L-239A was a log buried beneath 35 feet of clay about two miles due west of the locality described by Hack

(1965). They determined its age as 12,600 ± 1,200 years B.P. Another log at the same place under 80 feet of cover (M-359) was dated at only 10,220 ± 500 years B.P. (Crane, 1956). One can conclude that all the radiocarbon dates can not be accepted at face value. Re-evaluation of the dates has not been done. Neither is the writer in a position to evaluate the field relations of the dated material. The dates of bog filling on Glacial Lake Duluth seem reasonable. The significance of the older erratic wood in till or clay below may be questioned.

At the Porcupine Mountains three sets of striae are seen. The youngest is controlled by micro-bedrock topography and is not on Figure 1. An older set (1 at P on Fig. 1) shows ice moved southwestward and a younger set (2 at the same place) indicates a more southerly direction. The latter correlates closely with the fluted direction indicators in the Ontonagon Plains to the east. This relationship may be only coincidental. A border might be drawn around some of the clusters of parallel striae and direction indicators in the northern part of the Lake Gogebic lobe, especially in the Porcupine Mountains and adjacent plains fronting on Lake Superior, but no evidence of ice margins has been found in the lake plains of the central Gogebic lobe. However, the writer has done less study there than elsewhere in Upper Michigan.

Ice also seems to have existed locally in the Porcupine and Huron Mountains after the regionally deployed ice was destroyed, according to minor locally controlled striae that are later than the regional ones and to the freshness of various glacial forms produced by ice also locally controlled. However, the relationship of such ice to the latest Valderan ice suggested for the Ontonagon Plains is not known. Based on a morphological interpretation of land forms, the last ice of the Keweenaw lobe occupied the Baraga Plains where it wasted away _in situ_.

CONCLUSION

In conclusion it is clear that more than one interpretation of the age of the Huron Mountain, Keweenaw, and Lake Gogebic lobes may be derived from the evidence in hand. The writer prefers to call the Valderan front that of the Huron Mountain and Keweenaw lobes, and to ascribe latest Valderan ice to the Marquette lobe and to local areas in the Porcupine and Huron Mountains and the Baraga Plains. The Valderan front then, as the writer suggested in 1966, would extend across Lake Superior to Ontario to be correlated with the Hartman, Dog Lake, and Marks moraines of Zoltai (1965). This would confirm the suggestion earlier of Elson (1957) on the position of the Valderan border, and leave the west end of the lake open during Valderan time as was the south end of Lake Michigan. Some support for this interpretation is seen by comparison of the bottom topography of western Lake Superior versus that of the south end of Lake Michigan.

It may be that latest Valderan ice also occupied the Ontonagon Plains east of the Porcupine Mountains, terminating in the ancient drained lake plains to the south without leaving marked moraines. This would necessitate a change in the location of the ice front across Lake Superior. Further, the writer cannot really deny an interpretation that the south margin of the Lake Gogebic lobe is early Valderan and that the Keweenaw lobe is later Valderan. If so, conclusions from the study on weathering of the drifts in the various lobes are also incorrect. Obviously, further speculation at this stage in the research is hardly warranted.

The reconnaissance has defined a number of problems and problem areas which can be tackled with specific studies. Bog stratigraphy and radiocarbon dating particularly can now be done in conjunction with more detailed mapping in the western part of the Peninsula with some framework to tie to and to check. The area is too big to attempt such costly and time-consuming studies haphazardly.

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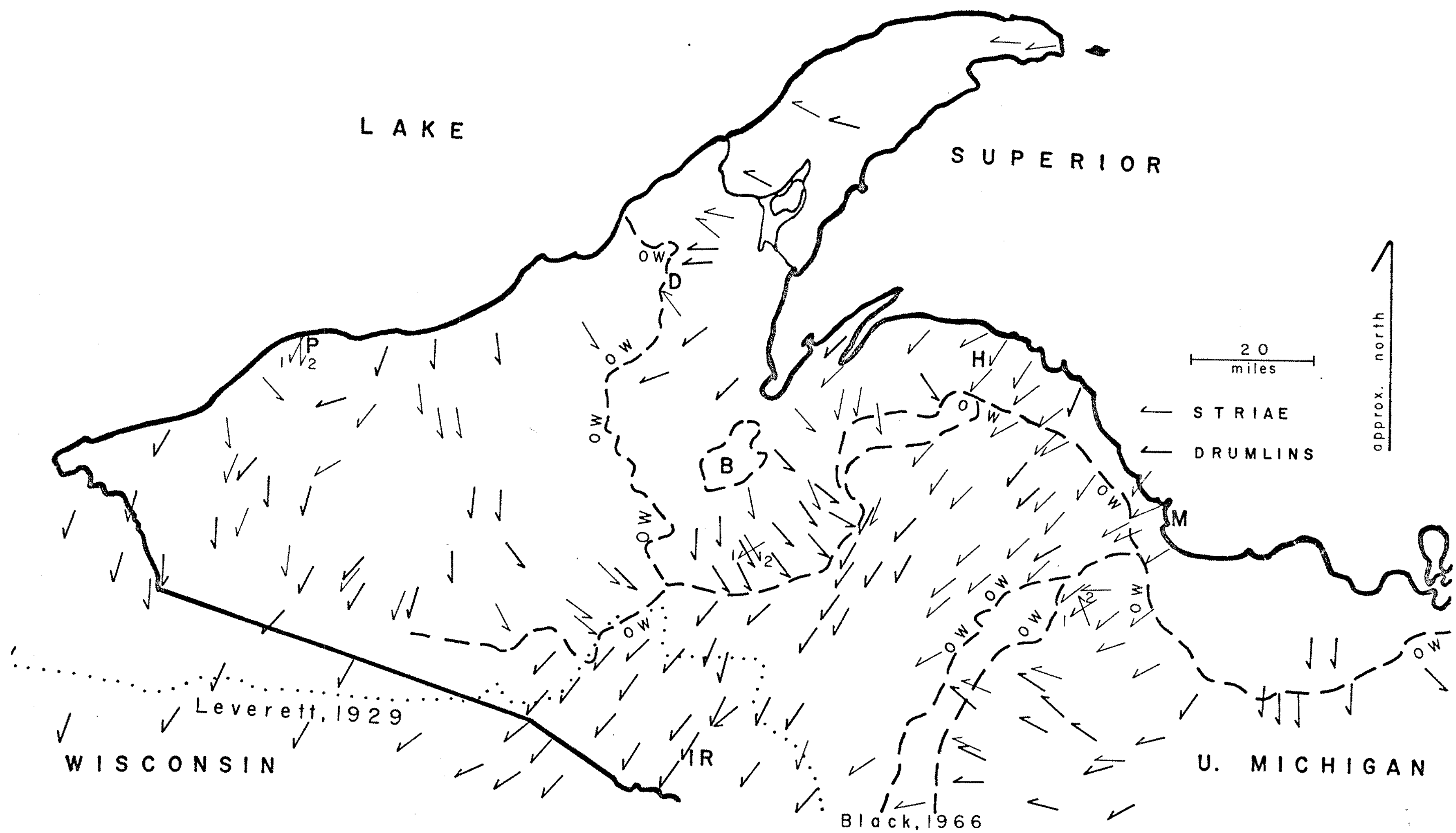
FIGURES

1. Sketch of part of western Upper Michigan, showing approximate boundaries between glacial lobes and representative direction indicators. Striae are cut in bedrock; drumlins include true drumlins, drumlinoid forms, and flutes in unconsolidated material. Leverett, 1929, and Black, 1966, are referenced in the text and show respectively the border of "red drift" and Valderan drift. M is Marquette, H is the Huron Mountains, D is Donken, P is the Porcupine Mountains, B is the Baraga Plains, IR is Iron River, and OW is outwash.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Leverett, 1929
Black, 1966
WISCONSIN
U. MICHIGAN

Black - Fig. 1