GLACIAL HISTORY OF THE GREENWOOD LAKE, ISABELLA, AND CRAMER QUADRANGLES, MINNESOTA

By

Howard C. Hobbs

Minnesota Geological Survey

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The following discussion of glacial history is keyed to a series of diagrams at the 1:250,000 scale, which represent significant points in a continuous evolution of events; some intermediate events are not shown.

The Toimi drumlin field on Diagram 1 (rtd on map) represents the oldest landforms and deposits exposed in the map area. The drumlins are streamlined northeast-southwest, and were molded under ice that flowed from the northeast. The drumlins have been attributed to the St. Croix phase of glaciation (Wright, 1972), but were probably formed after the ice had receded from the St. Croix moraine, because drumlins tend to form rather close behind the ice margin. The Rainy lobe ice margin may have been in the area subsequently covered by the St. Louis sublobe when the Toimi drumlin field was forming.

The inferred flow direction of the Superior lobe at this time was also from northeast to southwest, but no evidence for this flow direction now exists in the ice-molded topography of the Superior lobe. Instead, the molded topography reflects a younger ice-flow event that moved from southeast to northwest.

TEXT TO ACCOMPANY MINNESOTA GEOLOGICAL SURVEY OPEN-FILE MAP 88-2

During the time between Diagrams 1 and 2, the ice receded and probably stagnated. How far the ice receded is not known, but the margin probably was not far behind the positions of the subsequently formed moraines. The Highland moraine cannot be traced far behind its junction with the Isabella moraine in the Dumbbell Lake area. This implies that the edge of the Superior lobe formed an interlobate junction with ice of the Rainy Lake to the east of Dumbbell Lake. The Highland moraine trends southwest-northeast, but the boundary between the Superior and Rainy lobes turns east in the interlobate junction area. The Superior lobe was able to advance farther in the area where it was not pushing against another ice lobe.

The Superior and Rainy lobes (Diagram 2) then advanced to the Highland and First moraines, respectively. This advance, together with the subsequent glacial events described here, has been termed the Automba phase (Wright, 1972). A possible earlier ice margin beyond the First moraine is largely buried by outwash in the map area, but appears to connect with the Allen moraine to the southwest. The ice-flow paths were much altered from the flow direction in the St. Croix phase. The Rainy lobe, at least locally, advanced from the northwest, and the Superior lobe advanced from the southeast. The position and flow direction of the ice in between is uncertain, because the area was later covered by deposits of the Rainy-Superior sublobe.

Outwash streams flowed west from the Superior lobe in the southern part of the Isabella quadrangle, and turned north along the Stony River. The meltwater probably entered a glacial lake ponded between high ground to the southwest and ice to the east, north, and northwest. The meltwater probably overflowed to the west, and flowed out of the area to the southwest, along the First moraine. Meltwater may have entered this postulated lake by other paths as well, but any evidence has been hidden by later glacial and meltwater deposits.

Diagram 3 shows an ice advance from the northeast to the Outer moraine, while the ice flowing from the northwest was retreating to the Second moraine. The advance from the northeast was intermediate in direction between the Superior and main Rainy lobes, so it is here named the Rainy-Superior sublobe (of the Rainy lobe). This first advance of the Rainy-Superior sublobe deposited drift similar to that of the Superior lobe. This similarity must be largely the result of passing over Superior lobe outwash and glacial lake sediment. A possible contributing factor could be that as the Superior lobe thickened and rose out of the basin, some part of it passed over the divide in the area to the northeast and entered the domain of the Rainy lobe, and was incorporated into the nearest part of the Rainy lobe.

Superior-lobe meltwater flowing down the Stony River was diverted first northwest along the ice front and then southwest into a low area of the Toimi drumlin field, where it built a large outwash plain between McDougal Lakes and Sand Lake. The outwash plain probably continues westward out of the map area under extensive peat. Meltwater from the Rainy-Superior sublobe probably also contributed to this outwash plain; its outwash of Superior lobe lithology is not distinguished on the map from Superior lobe outwash.

In Diagram 4, the Rainy lobe remained at the Second moraine while the Rainy-Superior lobe was retreating to the Inner moraine. If meltwater was still flowing down the Stony River, its path was much as before; the Outer moraine was still diverting the drainage, even without ice behind it. At this time, the major drainage path was from the large Superior lobe esker complexes just south of the interlobate junction into the re-entrant between the Superior lobe and the Rainy-Superior sublobe. The meltwater was at first constricted by high ground to the southwest and ice to the northeast, and carved a gorge (ul) now occupied by the Isabella River. To the west, the flow was less constricted, and outwash spread out between the Inner and Outer moraines. It appears that the outwash continued between the First and Second moraines as well, but the evidence here is more ambiguous.

Diagram 5 shows the Rainy lobe retreating to the Third moraine (which correlates with the Vermilion moraine to the west). The Rainy-Superior sublobe had pulled back from the Inner moraine to the west, but remained at (or readvanced to) the Isabella moraine to the east. At this time, the Rainy-Superior sublobe started depositing material typical of the Rainy, rather than the Superior lobe. Presumably, the limited supply of debris derived from the Superior basin was now exhausted, and new material supplied to the ice front now had the character of the Rainy lobe. The Isabella moraine is mantled with reworked till of Rainy lobe rock types. The Isabella moraine is interpreted to be cored by Superior-type till of the Inner moraine, but no exposures of it have been observed. The gorge of the Isabella River was still active at this time; it may actually have formed at this time, if the Inner moraine ice front of Diagram 4 was farther north and did not constrict meltwater flow.

As the Rainy lobe retreated, its ice margins pivoted clockwise around its approximate junction with the Rainy-Superior sublobe. The flow direction had shifted from northwest-southeast to north-south by the time of Diagram 5, and that interlobate junction is therefore not shown. However the flow paths never quite became parallel within the map area.

Three esker systems of the Rainy-Superior sublobe came together in an ice-contact complex in the re-entrant where the Isabella moraine meets the First moraine. The outwash (ro) deposited just outside the assumed ice margin at this time has a shape similar to that of a jokulhlaup fan (J.D. Lehr, personal communication), which indicates that subglacial meltwater may have drained rapidly from the glacier when an ice dam was breached. Some of this meltwater may have escaped through a breach in the Inner moraine, but most of it probably flowed west, where its deposits are included in unit uo. Farther west, large amounts of meltwater were discharging from two large esker systems in the Rainy lobe, and flowing west off the map area between the ice front and the Second moraine. The outwash must have been deposited on stagnant ice, because it is highly collapsed.

Diagram 6 shows the Rainy lobe still at the Third moraine, although the flow from the eskers has diminished, and the Rainy-Superior sublobe has withdrawn behind the Isabella moraine. The outer edge of the Superior lobe has stagnated, and the active ice has withdrawn from the Highland moraine.

Now the meltwater from the big Superior lobe esker complexes has found a somewhat lower path between the ice margin and the Isabella moraine. Part of this path is map unit so, and the part where constricted meltwater has cut a gorge now occupied by Hill Creek is included in unit ul. Downstream from the Hill Creek gorge, the outwash is mapped uo, to reflect the addition of meltwater from the ice-contact complex near Mitiwan Lake. Downstream from Slate Lake, the uo unit is distingushed from the earlier outwash mapped ro by its lower elevation and lack of collapse pits. The ice under this area melted out in the time between Diagrams 5 and 6.

By the time of Diagram 7, the Rainy lobe had disappeared from the map area, and the Rainy-Superior sublobe was much reduced. The Superior lobe was retreating, but it still occupied most of its former area, and was sending meltwater through the area formerly occupied by the Rainy-Superior sublobe. Essentially, the story of the Isabella and Hill Creek drainageways was repeating itself, but at lower elevations and with smaller volumes of water, as the ice front retreated to the northeast. After the Hill Creek drainageway was abandoned, the water was no longer able to flow west, but was diverted to the north, the direction of modern drainage. The outwash connot be traced precisely through this area, because the low areas in which it was deposited are now covered with peat.

The Rainy-Superior sublobe built a large outwash plain southwest of Silver Island Lake, fed by esker systems on the east side and by runoff from the ice front on the north side. The outwash was apparently held back by stagnant ice on the northwest, because the adjacent till plain is lower in elevation than the outwash plain. The highly collapsed surface of the outwash plain indicates that stagnant ice was also present under the outwash.

Subsequent glacial events in the map area did not leave distinctive geomorphic features, and the deposits are largely basal till left behind as the ice melted.

To sum up the above glacial history, the Superior lobe advanced into the area from the southeast and built a broad moraine, at which it remained until the final melting episode. The Rainy lobe and its sublobe behaved much differently; they advanced from the northwest and northeast, and built a series of narrow moraines which reflect much shorter periods of stability. There appears to be a general contrast between the Rainy and Superior lobes, which explains their shapes: the Superior lobe was narrow and thick, because it occupied the Lake Superior basin, and so it reacted conservatively to changes in ice flow and ablation. The Rainy lobe was wide but thin, because its base was higher, even though its surface may have been roughly as high as that of the Superior lobe; thus it was more sensitive to changes in ablation and ice flow.

The key to understanding the many changes in meltwater flow direction is that the ice generally was flowing uphill. Meltwater was blocked by ice from flowing toward the lowest elevations, and so it tended to flow parallel to ice margins. As the ice margins changed, so did the meltwater flow paths.

Compilation

The map is based on three Master's theses done at different times at different institutions with different faculty advisors. The senior author revised each of the thesis maps according to geomorphology and to make them consistent with each other. He also mapped the southern half of the Greenwood Lake quadrangle by geomorphology alone. Field work in the area was patchy, due to difficulties of access. Thus, much of the map is interpretive.

The moraine terminology was retained from the thesis maps. The major mapping units from the thesis maps were little modified. Hobbs made the distinction between outwash and ice-contact sand and gravel in the thesis areas of Stark and Fenelon, who had combined the units as glaciofluvial. The interpretations of ice fronts, and ice and meltwater flow directions presented in the diagrams are those of Hobbs and do not completely agree with those in any of the three theses.

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Stark, James R., 1977, Surficial geology and ground-water geology of the Babbitt-Kawishiwi area, northeastern Minnesota with planning implications: Unpublished Master's thesis, University of Wisconsin-Madison (map covers a larger area than was used here).

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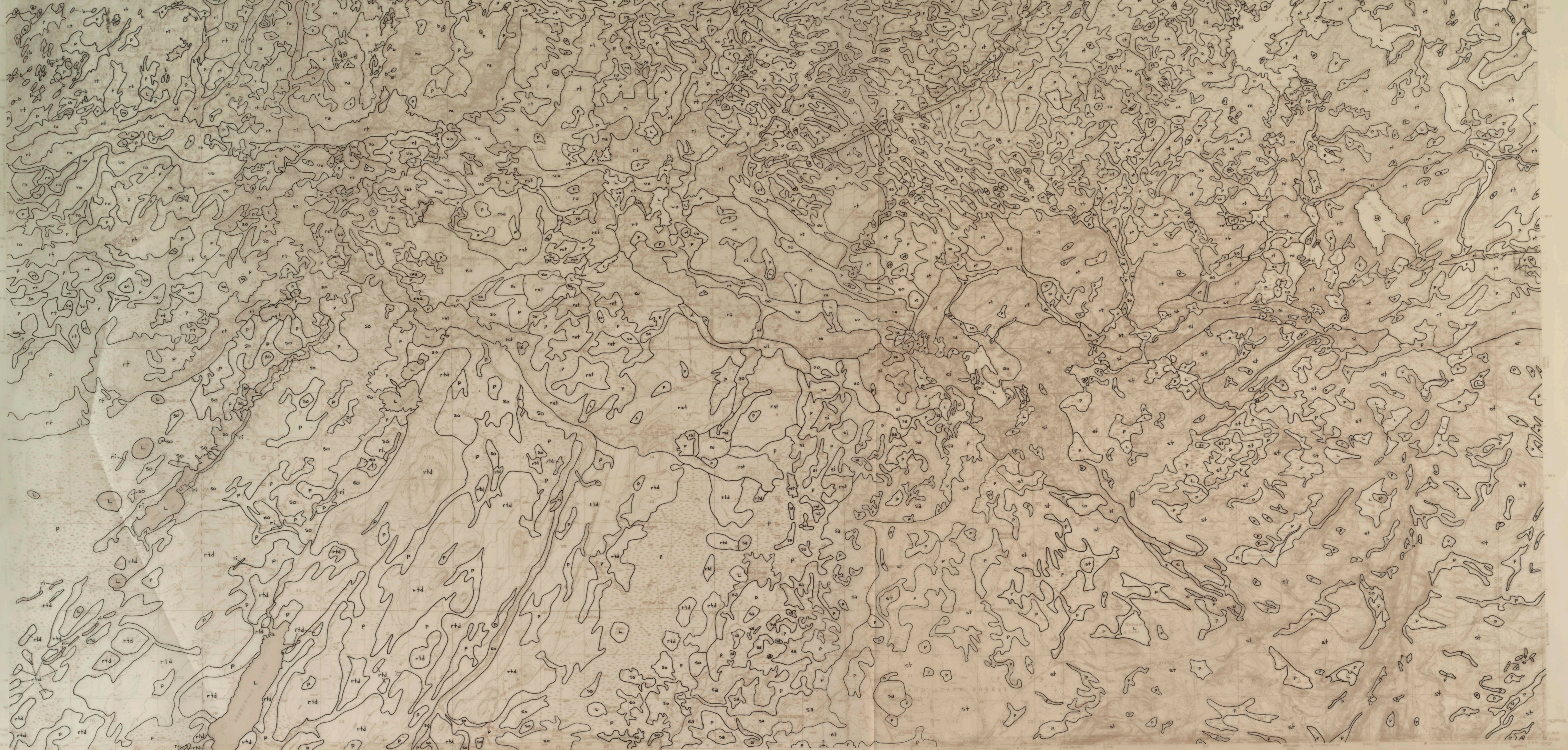
UNIVERSITY OF MINNESOTA
MINNESOTA GEOLOGICAL SURVEY
Priscilla C. Grew, Director

SURFICIAL GEOLOGIC MAP OF THE GREENWOOD LAKE, ISABELLA, AND CRAMER QUADRANGLES, MINNESOTA

By
Howard C. Hobbs, Albert L. Friedman, Joseph M. Fenelon, and James R. Stark

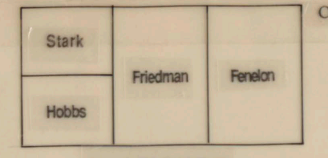
Prepared for the Minnesota Department of Natural Resources, Division of Minerals, June 1988

OPEN-FILE MAP 88-2



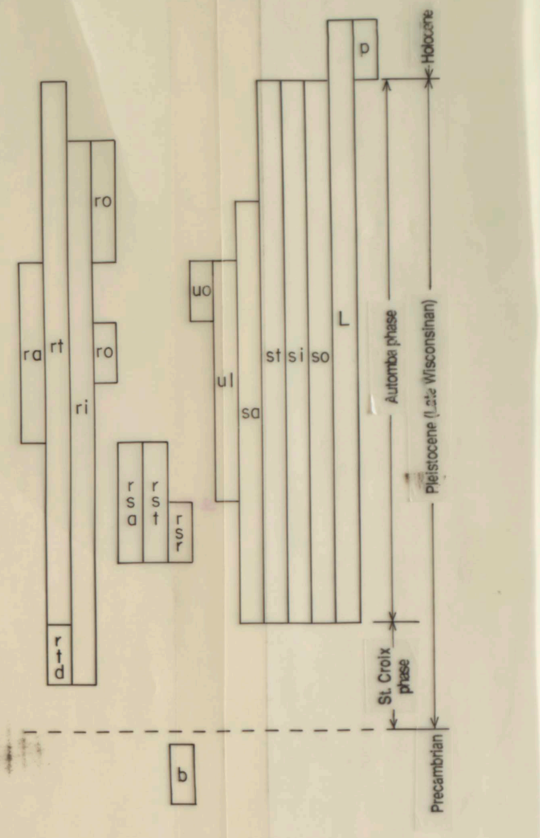
Base modified from U.S. Geological Survey Greenwood Lake (1954), Isabella (1955), and Cramer (1955).

Compiled by H.C. Hobbs, 1988.



INDEX TO MAPPING

CORRELATION OF MAP UNITS



DESCRIPTION OF MAP UNITS

L, LAKES—Shown only where larger than about 10 acres.

p, PEAT—Organic material ranging from fibric to sapric. Thickness ranges from less than 1 meter to about 5 meters. Occurs in depressions and poorly drained flat areas. Includes small islands of mineral soil.

RAINY LOBE AND RAINY-SUPERIOR SUBLOBE DEPOSITS—Noncalcareous drift composed predominantly of fragments of the Duluth Complex (troctolite and anorthosite) and granite. Color ranges from gray (2.5Y) to brown (10YR).

The user should note that all of the mapped units except lake sand peat are capped by a layer of slightly pebbly silt and very fine sand, ranging from 0.25 m to 0.75 m thick. The brown color (10YR) of the loess matches the hue of the Superior lobe deposits. This eolian deposit is apparently derived from dust blown from outwash and exposed glacial lake plains.

rt, Till—Unsorted rocky gravelly loamy sand. Clasts are angular to subangular, and tightly packed. Deposited by glacial ice with little or no reworking by meltwater.

ra, Reworked till—Poorly sorted bouldery sandy gravel and gravelly sand. Clasts are somewhat rounded and loosely packed. Deposited by glacial ice with considerable reworking by meltwater.

ri, Ice-contact deposits—Moderately to well-sorted and stratified sandy gravel and gravelly sand, containing cobbles and boulders in places. Clasts are rounded and loosely packed. Deposited by glacial meltwater under and adjacent to ice.

ro, Outwash—Similar to ice-contact deposits, but carried beyond the ice front and deposited. Collapsed in places, due to subsequent melting of underlying stagnant ice.

rtd, Drumlinized till—Similar to unit rt, but deposited by an earlier advance in the Toimi drumlin field.

SUPERIOR LOBE AND RAINY-SUPERIOR SUBLOBE DEPOSITS—Noncalcareous brown to reddish-brown (10YR, 7.5YR and 5YR) drift composed of subequal proportions of rock fragments from the North Shore Volcanic Group (rhyolite, basalt, and microgranite), the Duluth Complex, and granite.

st, Till—Unsorted gravelly sandy loam; contains some cobbles and boulders, but a smaller proportion than in the till of the Rainy lobe. Deposited by glacial ice with little or no reworking by meltwater.

rst, Till—Similar to unit st, but deposited by the Rainy-Superior sublobe.

sa, Reworked till—Poorly sorted gravelly sand, containing a few cobbles and boulders. Deposited by glacial ice with considerable reworking by meltwater.

rsa, Reworked till—Similar to unit sa, but deposited by the Rainy-Superior sublobe.

si, Ice-contact deposits—Moderately to well-sorted and stratified gravelly sand and sandy gravel.

rsi, Ice-contact deposits—Similar to unit si but deposited by the Rainy-Superior sublobe.

so, Outwash—Moderately to well-sorted and stratified gravelly sand and sandy gravel.

DEPOSITS CONTAINING MATERIAL FROM BOTH LOBES

uo, Outwash—Sorted and stratified gravelly sand and sandy gravel.

ul, Lag deposits—Rounded cobbles and boulders lacking fine- to medium-grained material. Derived largely from underlying till in areas that were downcut by constricted meltwater streams.

b, BEDROCK OUTCROPS—Surface exposures of Duluth Complex rocks. Mapped only in the northern half of the Greenwood Lake quadrangle. Outcrops were not observed in the Isabella quadrangle; probably rare in the southern half of the Greenwood Lake quadrangle. Outcrops are common in parts of the Cramer quadrangle but were not mapped there.

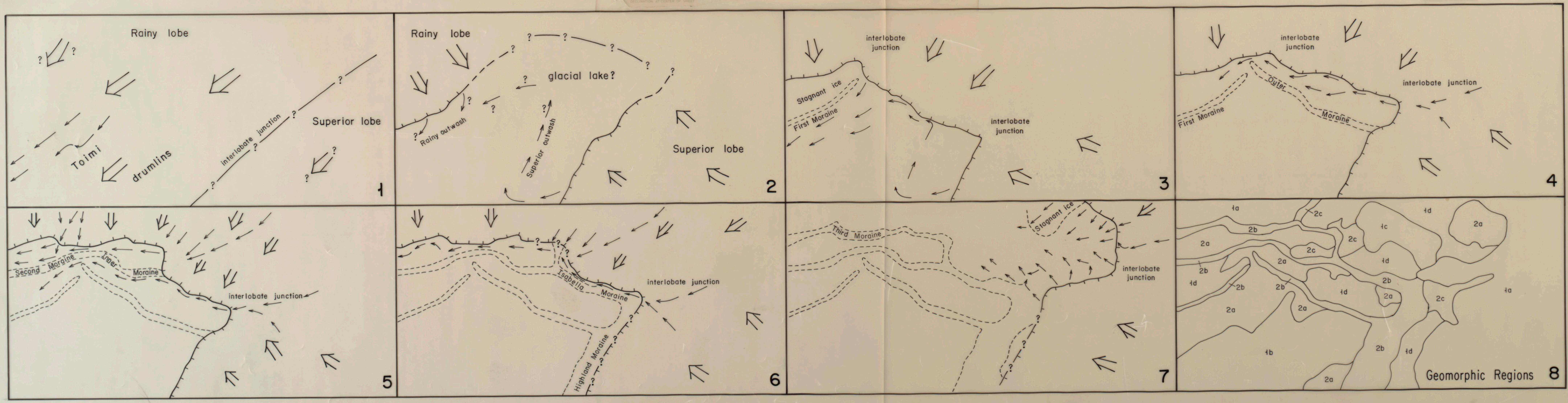


DIAGRAM SYMBOLS

(See accompanying text for discussion of glacial events shown in Diagrams 1 through 7)

Ice margin; dashed and queried where approximate; hachured toward the [illegible] represents active ice; stagnant ice persisted in [illegible] after active ice had retreated. Stagnant ice is labeled on Diagrams 4 and 7, but it does not represent all the times and places that stagnant ice was present.

Moraine exposed by retreating ice. Labeled only where first shown.

Ice-flow direction; queried where uncertain. "Interlobate junction" is the approximate boundary between adjacent ice masses having different flow directions. An interlobate junction between the Rainy and Superior lobes is shown in Diagram 1, even though the ice-flow direction is inferred to be the same; it represents the approximate boundary between the dominant rock types.

Meltwater flow direction; queried where uncertain. Represents both the outwash flow paths and the englacial flow paths where reflected by eskers and kame complexes. Where several flow paths are shown on one diagram, they are inferred to have occurred at about the same time. Minor flow paths are not shown, but their timing and direction can be approximated by comparing the geologic map with the diagrams.

GEOMORPHIC REGIONS

Ice-molded topography

1a, Bedrock-dominated—Bedrock surface determines land surface. Drift mainly thin basal till. Outcrops common.

1b, Drumlins—Topography streamlined parallel to ice flow; surface drift is basal till; some drumlins may be cored with rock, especially the higher and steeper ones, but most are made of drift.

1c, "Rogen" moraine—Minor, discontinuous ridges of basal till transverse to ice flow direction.

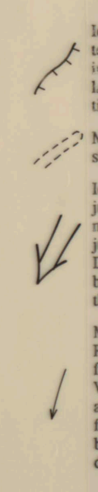
1d, Other—Appears to be primarily basal till at the surface, but is fairly flat and irregular.

Superglacial and Extraglacial Topography

2a, Outwash—Only large areas are shown. Ranges from flat to collapsed.

2b, End moraines—Thick drift deposited close to an ice margin. Includes till, reworked till, and ice-contact stratified drift. Basal till, if present, is buried by superglacial deposits.

2c, Other—Mainly reworked till and ice-contact stratified drift not deposited at an ice margin.



MGS OFR 88-2 Single sheet; see also nine-page accompanying text