LATE WISCONSINAN GLACIAL LAKES OF THE WESTERN MOHAWK VALLEY REGION OF CENTRAL NEW YORK

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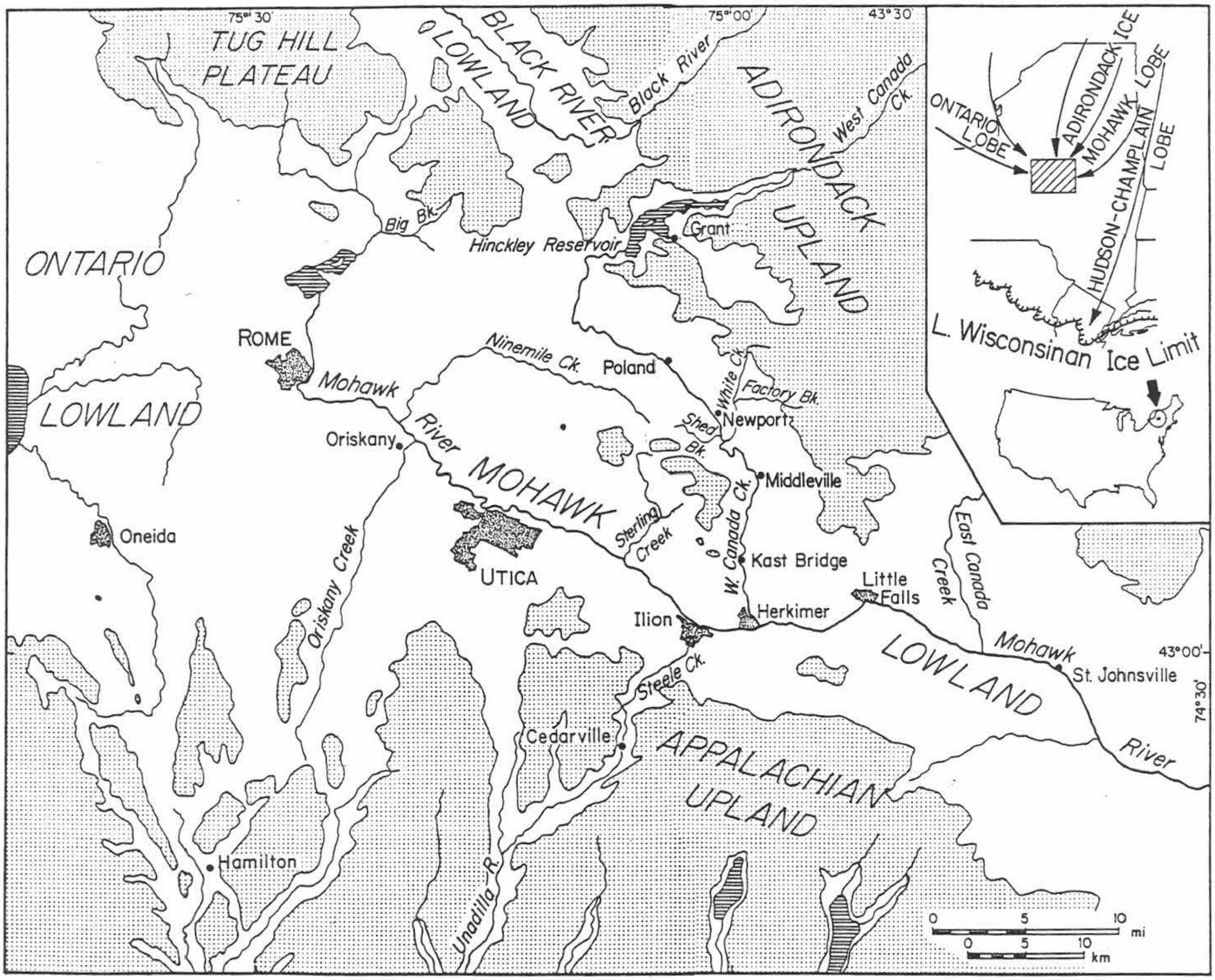


FIGURE 1. Location map of the western Mohawk Valley region of central New York. Patterned areas indicate uplands above an elevation of 400 m.

INTRODUCTION

The glacial history of the western Mohawk Valley region (Fig. 1) is critical to evaluating the contemporaneity of glacial events in the Great Lakes region, the Hudson-Champlain Valley, and New England. Understanding the composition and stratigraphy of glaciolacustrine deposits is particularly important to defining the positions and advances of impounding ice lobes, the pattern of ice recession in the Ontario Basin, Mohawk Valley, and Adirondacks, and the timing of the eastward release of water from the eastern Great Lakes region during Late Wisconsinan time.

Until recently, considerable controversy existed over the character of ice recession and the existence of regional glacial lakes and their levels in the Mohawk Valley. Several early workers recognized the widespread evidence for eastward (Ontario Lobe) and westward (Mohawk Lobe) ice flow in the Mohawk Valley (Dana, 1863; Chamberlin, 1883, 1888; Brigham, 1898, 1908; Cushing, 1905; Miller, 1909). A lack of deposits that clearly define ice-marginal positions in the Mohawk Valley led Cushing (1905), Brigham (1911, 1929), and Fairchild (1912) to conclude that ice in the lowlands receded by stagnation and downwasting, rather than by backwasting of an active ice margin. Fairchild's (1912) reconstructions depict lowland ice lobes that surrounded an ice-free Adirondacks during deglaciation. Fairchild inferred that deep glacial lakes, which drained southward across the Appalachian Upland, were impounded between the Mohawk and Ontario Lobes (Fig. 1) during deglaciation. Brigham (1911, 1929) opposed this idea based on a scarcity of lacustrine deposits above an elevation of 200 m. Recent stratigraphic studies (Fullerton, 1971; Krall 1977; Franzi, 1984; Ridge, 1985; Muller and others, 1986; Ridge and others, 1990; 1991) have provided evidence that deep, regional proglacial lakes formed at the margins of active lowland ice lobes at elevations up to 475 m. The lowland lobes formed prior to the deglaciation of most of the central Adirondack highlands. Regional deglaciation occurred primarily by calving at deep water, active ice margins, but was interrupted by several episodes of lowland ice readvance.

The purpose of this excursion will be to examine the evidence and history of glacial lakes in the western Mohawk Valley region. The lithostratigraphic model for the West Canada Creek valley, the application of paleomagnetism, and the genetic interpretation of sediments as related to glacial dynamics will be discussed.

METHODS AND ANALYSIS

A brief review of the fundamental concepts and nomenclature that provide the basis for interpretations of glaciolacustrine history is necessary before discussing the glaciation of the western Mohawk Valley. Essentially, most interpretations are based on detailed lithostratigraphic analysis of glacial sediments in the West Canada Valley and morphologic analysis of deltaic landforms and spillways. Perhaps the most important recent development is the formulation of regional time-stratigraphic correlations based upon radiocarbon-dated paleomagnetic stratigraphy.

Lithostratigraphy

Because of its completeness and lateral continuity the lithostratigraphic section of the West Canada Valley (Fig. 2) has been the foundation for the interpretation of the glacial history of the western Mohawk Valley (Franzi, 1984; Ridge, 1985; Muller and others, 1986; Ridge and others, 1990, 1991). The definitions and nomenclature of stratigraphic units in the West Canada Valley are non-genetic to avoid the confusion, misinterpretation, and ambiguity associated with genetic terms. Continuous packages of sediment bounded by discontinuities are defined as formations that can be subdivided into members. Members include stratified units, signified as "beds" that range from clay and silt to bouldery

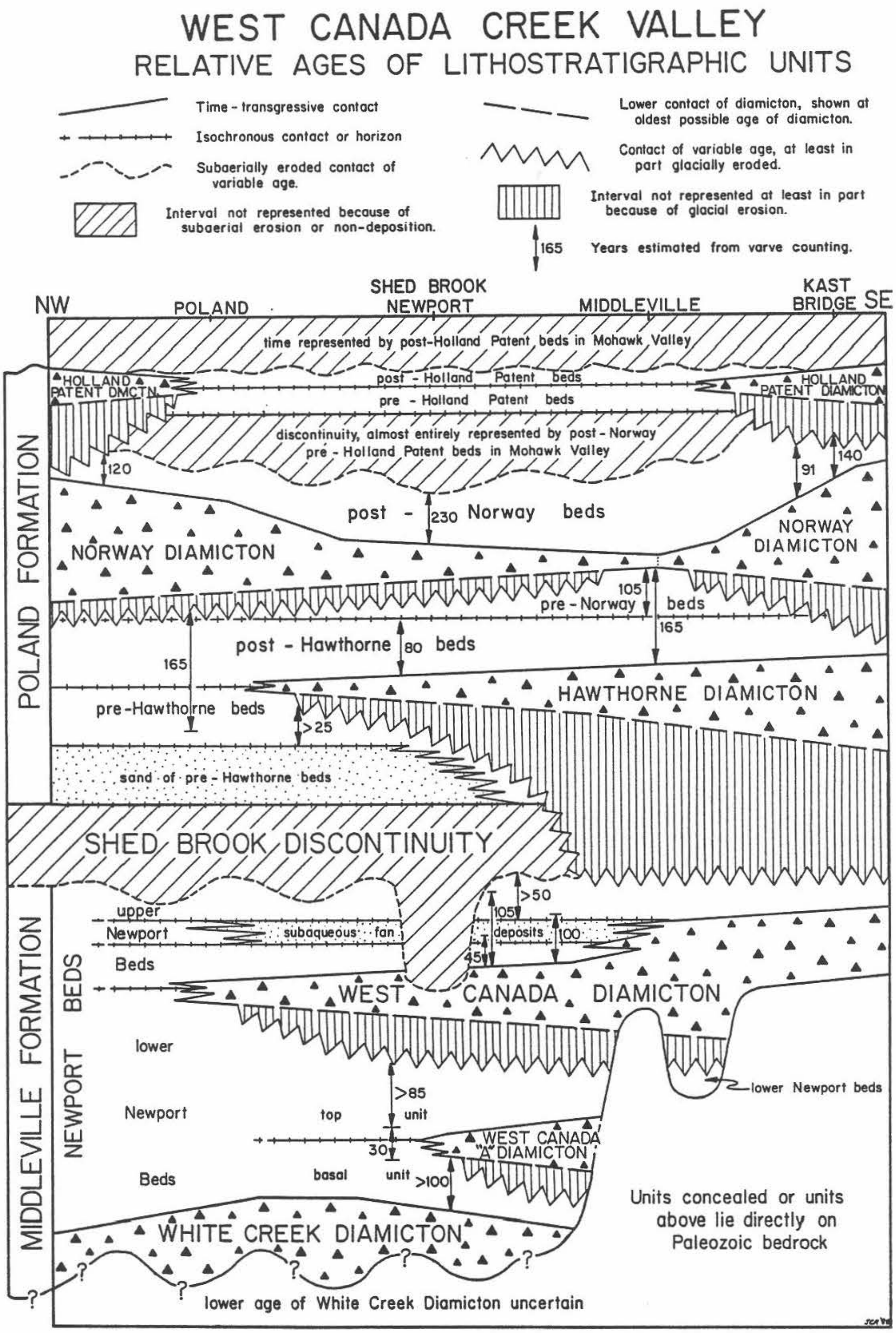


FIGURE 2. Summary of late Wisconsinan lithostratigraphy along the axis of the West Canada Valley. Lithostratigraphic units are plotted versus relative time on the vertical axis and position in the West Canada Valley on the horizontal axis to show the time-transgressive properties of some of the units. Place names are given on Figure 1.

gravel, and diamicton units. The non-genetic term "diamicton", following the usage of Frakes (1978) as a nonlithified, poorly sorted mixture of clay to boulders, has been chosen, instead of "till" because it more accurately describes units which are composed of till and poorly sorted sediment of other origins.

Provenance and Ice Flow Direction

The source and flow direction of ice lobes associated with individual diamicton units is recorded by striations on bedrock, subglacial grooves on the upper surfaces of till, elongate landforms, till fabrics, the sense of displacement on deformation structures in glacially overridden sediment, pebble provenance, and the color and composition of diamicton matrix material. Diamicton clast and matrix compositions are dominated by local rock types. In many places provenance differences are not distinct in the field because opposing ice lobes may have overridden the same rock types, or glacial readvances reworked older diamicton units. Detailed pebble counts and geochemical data, combined with ice flow indicators, provide the most accurate and consistent identification of ice lobe source for all the diamicton units (Fig. 2; Franzi, 1984; Ridge, 1985; Ridge and others, 1991). In general, Ontario Lobe diamictons contain the highest percentage of clastic sedimentary rocks and may have a matrix with a tannish gray to red color reflecting a western source. Mohawk Lobe diamictons are generally very dark gray to black and are dominated by black calcareous shale and dark gray limestone pebbles. Adirondack ice deposited sandy diamictons with high percentages of pebbles composed of metamorphic rock types that become more abundant as one approaches the Adirondacks. Locally derived materials may complicate the general compositional trends outlined above. For instance, in the West Canada Valley, Ontario Lobe ice transported non-calcareous shale pebbles from the summits of the Deerfield Hills to positions to the east while the Mohawk Lobe deposited diamictons with little non-calcareous shale.

It has been possible to distinguish the sources of fine-grained, varved lacustrine sediment based on field observations of color, grain-size, and the composition of ice-rafted debris. Ice-rafted debris includes pebbles and pellets (Ovenshine, 1970) that melted out of debris-laden icebergs. The iceberg debris probably originates as basal debris bands or subglacial sediment adhered to basal ice after calving. Lacustrine beds associated with the Ontario Lobe are light to medium gray in color with subtle pink to red hues and contain both gray and red ice-rafted pellets. Mohawk Lobe beds are generally dark to medium gray in color and contain only gray pellets. Varved sediment of an Adirondack provenance contain very thin bluish to greenish gray clay laminae with coarser beds that contain a high percentage of light gray fine sand.

Paleomagnetic Stratigraphy

A paleomagnetic record has been formulated for the Late Wisconsinan lithostratigraphy of the western Mohawk Valley from the detrital remanent magnetization of clayey and silty lacustrine beds that record the declination of the geomagnetic field at the time of deposition (Fig. 3; Ridge, 1985; Ridge and others, 1990). The secular variation record of remanent declination can be used to characterize intervals of time represented by different stratigraphic units. Paleomagnetism allows a time-dependent test of stratigraphic correlations of laminated lacustrine clay and silt at different outcrops based upon declination values and systematic stratigraphic changes in declination. Paleomagnetic declinations are unique in some stratigraphic units and provide strong supporting evidence for their identification. Examples of units with unique remanent declinations are the upper Newport Beds, which have a 20-30° East declination, and the upper part of the post-Holland Patent beds which have a 20-30° West declination. A gap in the declination record (Fig. 3) between the upper Newport Beds (20° East)

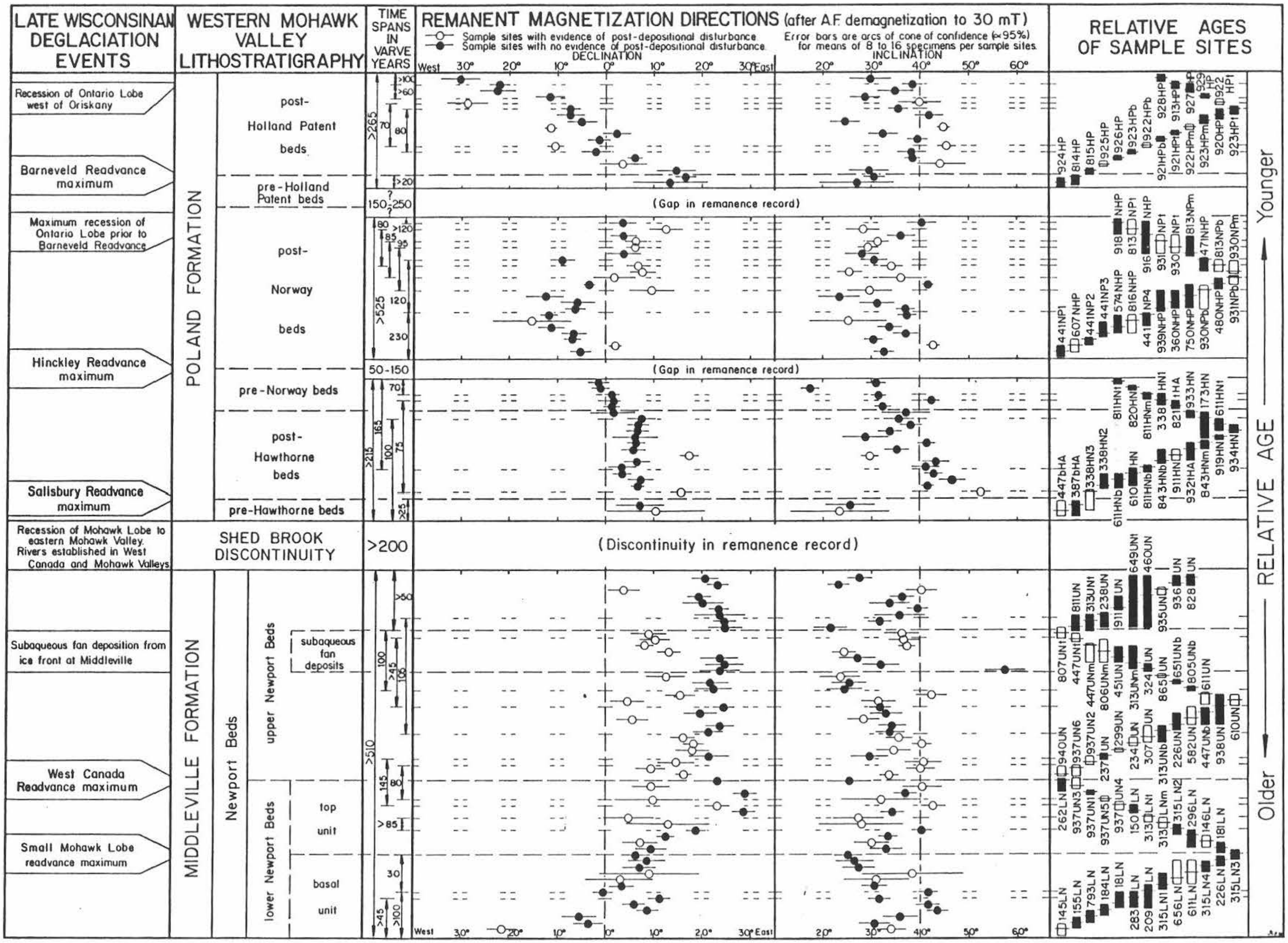


FIGURE 3. Plot of mean remanent declination and inclination for sampling sites in the western Mohawk Valley from Ridge and others (1990). Precise locations of sampling sites are given in Ridge (1985). The possible overlap of relative ages of sampling sites are shown with a bar graph on the right side of the diagram.

and the overlying pre-Hawthorne beds (8° East) provides additional evidence for an unconformity at the Shed Brook Discontinuity (Fig. 2). Remanent inclination is not a useful correlation tool because it tends to be inconsistent and underestimates the inclination of the geomagnetic field at the time of deposition (Fig. 2; Ridge and others, 1990). The apparent flattening of inclination is probably due to depositional or post-depositional processes in different sediment types.

Chronologic Inferences

Paleomagnetic records have been formulated from glaciolacustrine deposits from central New York (Brennan and others, 1984; Ridge, 1985; Ridge and others, 1990) and glacial Lake Hitchcock in the Connecticut Valley of western New England (Johnson and others, 1948; Verosub, 1979; Ridge, unpublished data; Fig. 4). The varve sediments of glacial lakes Hitchcock, Merrimack, and Ashuelot in New England, and Lake Albany in the Hudson Valley were studied by Antevs (1922) in his formulation of the New England varve chronology (Fig. 4). The paleomagnetic records permit a crude regional correlation of glacial events, but more importantly, radiocarbon calibration of the New England varve chronology (Ridge and Larsen, 1990) provides linkage to a numerical time scale. Radiocarbon-calibrated paleomagnetic records that are tied to the New England varve chronology may provide an important new tool that can be applied to the Late Wisconsinan lithostratigraphy and events of central New York. For example, the only existing radiocarbon dates from the New England varve chronology of about 12.4 ka (Varve yr 6150) are from sediments that have a unique greater than 30° West declination (Fig. 4). These sediments correlate paleomagnetically with pre-Lake Iroquois sediment in the eastern Ontario Basin (Brennan and others, 1984) that has a radiocarbon age of 12.8-12.3 ka (Fullerton, 1980; Muller and Prest, 1985). At present, this is the only independent test of the paleomagnetic correlation between central New York and New England and thus should be considered preliminary.

Glacial Lake Reconstruction and Isostatic Rebound

Two major obstacles have historically prevented accurate reconstructions of glacial lakes in the western Mohawk Valley region. First, glacial lakes associated with older events in the valley are not usually represented by landforms which can be used to delineate ancient strandlines. Strandline features may have been obliterated by later glacial readvances or the glacial lakes were simply too deep in the central part of the Mohawk Valley. The minimum levels for older lakes are inferred from the maximum elevations of buried lake floor deposits and subaqueous sand and gravel deposits.

A second problem has been the uncertainty in the positions of spillways for high level lakes because of uncertainties in the direction and magnitude of isostatic tilting in the region. The degree of tilting in the region is at least 0.8 m/km (4.3 ft/mile) based on the areal distribution and elevations of deltas associated with glacial Lake Miller in the upper West Canada Valley. Reconstructed glacial lake planes in the eastern Ontario Basin generally slope southwest with isobases (lines of equal uplift) oriented west-northwest to east-southeast (Fairchild, 1916, 1917; Pair, 1986; Pair and others, 1988). Isobases in New England trend east-northeast to west-southwest (Koteff and Larsen, 1989). By inference, isobases in the western Mohawk and Hudson valleys must be oriented between those in the Ontario Basin and New England. An inferred direction and magnitude for tilting of lake planes in the western Mohawk Valley region (south-southwest at 0.8-1.0 m/km; Fig. 5) is used to reconstruct the extent and elevation of former glacial lakes.

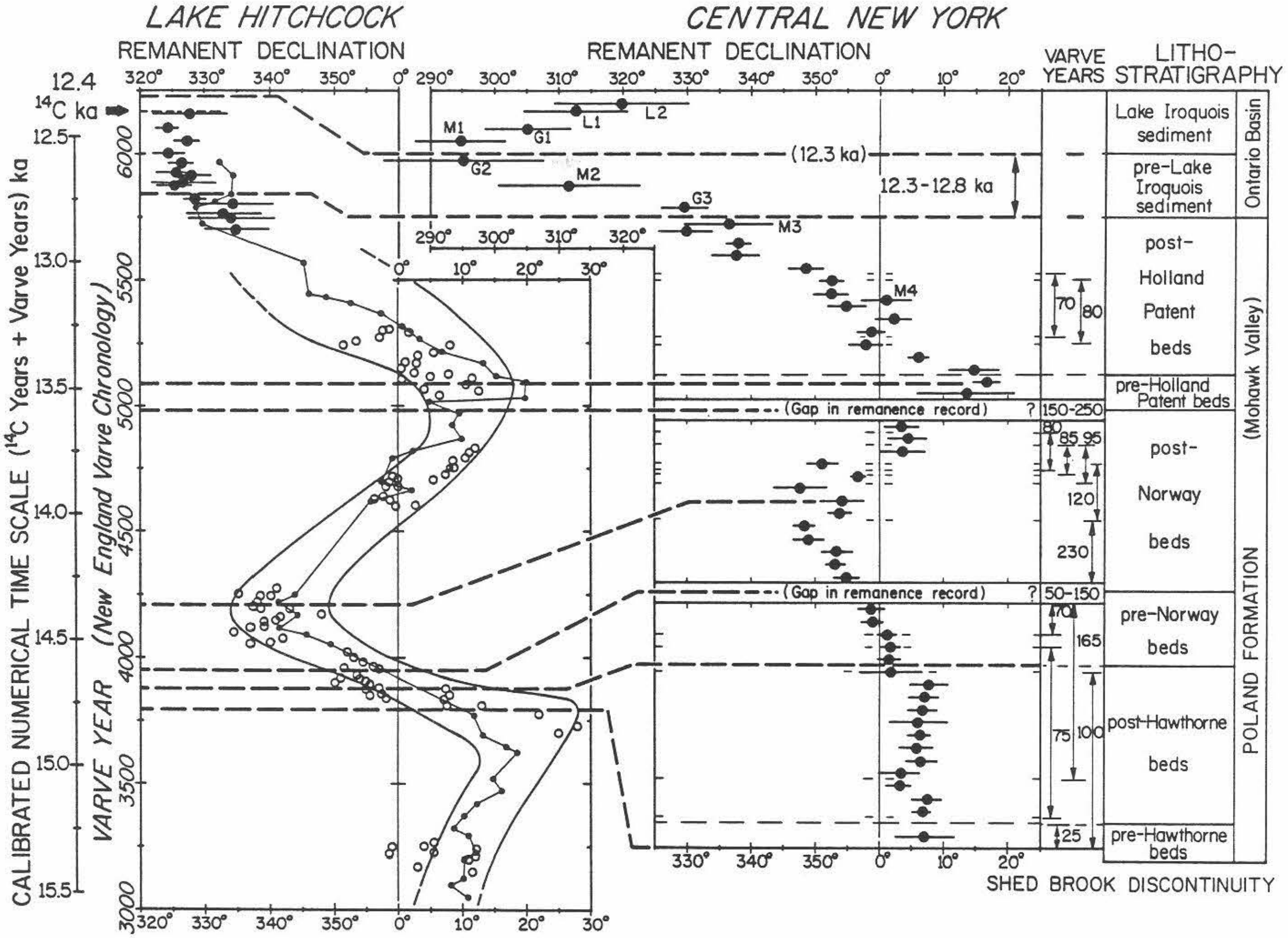


FIGURE 4. Correlation (heavy dashed tie lines) of remanent declination records from lacustrine deposits of Lake Hitchcock in western New England and central New York. Lake Hitchcock records are from sections matched with the New England varve chronology (varve yrs 3000-6250; Antevs, 1922). Radiocarbon calibration is based on radiocarbon ages of 12.4 ka from Canoe Brook, Vermont (Ridge and Larsen, 1990). The area between the two smoothed curves on the Lake Hitchcock record represents the region within which geomagnetic declination lies as interpreted by Verosub (1979) from natural remanences (Johnson and others, 1948; solid circles with tie line) and remanences (Verosub, 1979; open circles). Remanent declination means from sites in couplets 5700-6200 (new data from Canoe and Mill Brook sections in Vermont) are shown as large solid circles with alpha-95 confidence intervals. From central New York, unlabeled declination means and alpha-95 confidence intervals (Ridge and others, 1990) and labeled sites (Brennan and others, 1984) are plotted by relative age as indicated by position in superposed lithostratigraphic units or morphologic successions in the western Mohawk and West Canada Valleys (Figs. 2 and 3; Ridge and others, 1990) and the eastern Ontario Lowland (Fullerton, 1980). Numerical ages of pre-Iroquois and Lake Iroquois sediments are based on Fullerton (1980) and Muller and Prest(1985).

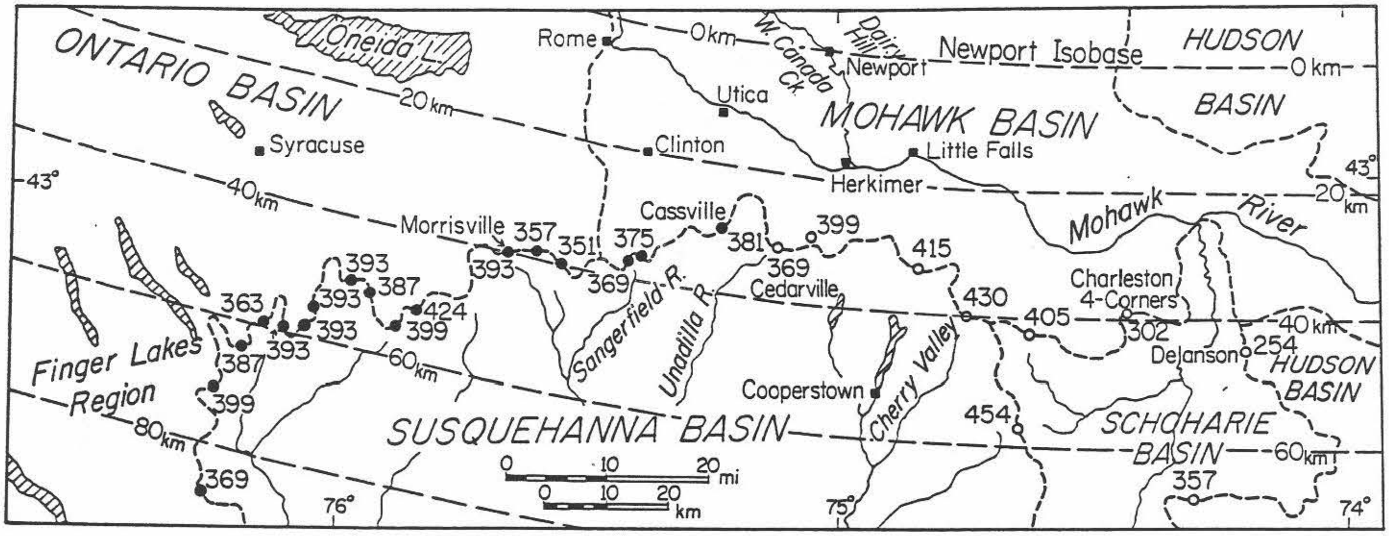


FIGURE 5. Potential lake-draining cols on the Ontario, Mohawk, and Schoharie basin boundaries. All elevations are in meters as converted from USGS 1:24,000-scale topo maps. Cols known to be filled with Valley Heads drift (Randall and others, 1988) are indicated with solid symbols. Inferred isobase trends are shown with isobases spaced 20 km apart, starting in the north with an isobase through Newport.

LATE WISCONSINAN GLACIATION AND GLACIAL LAKES

The Late Wisconsinan glaciation of the western Mohawk Valley region is mostly recorded by two sequences of glacial sediment, separated by an unconformity, that represent major periods of Mohawk and Ontario lobe oscillation. The older sequence is the Middleville Formation, dating from prior to 16 ka, which represents the pre-Valley Heads glaciation (Fig. 2; Ridge, 1985; Ridge and others, 1991). The younger sequence is the Poland Formation (Fig. 2) which represents Valley Heads glaciation (Mickelson and others, 1983) and dates from about 15-13 ka as inferred from paleomagnetic correlations with radiocarbon-dated varves in New England (see previous section: Chronologic Inferences).

Early Pre-Valley Heads Glaciation

The only known complete record of pre-Valley Heads glaciation in the western Mohawk Valley is the Middleville Formation in the West Canada Valley (Ridge, 1985; Ridge and others, 1991). The earliest records of pre-Valley Heads glaciation are southwest ice flow indicators and sandy till containing abundant metamorphic rock in the base of the White Creek Diamicton (Fig. 2). These features may represent the maximum Late Wisconsinan advance to or recession from the Terminal Moraine in Pennsylvania (Lewis, 1884; Crowl, 1980; Crowl and Sevon, 1980; Cotter and others, 1986). Later deposition of till in the White Creek Diamicton indicates a shift in ice flow direction to the south to south-southeast as local subglacial topography exerted a greater influence on ice flow (Fig. 6).

Development of Lake Newport and Mohawk Lobe Readvances

Initial ice recession in the West Canada Valley produced an opening in the retreating ice sheet which is recorded by lacustrine deposition of the lower Newport Beds in the beginning of Lake Newport (Figs. 2 and 6). Sedimentation in Lake Newport continued throughout pre-Valley Heads glaciation. For much of its existence the level of Lake Newport was too high, considering southward projection of isostatically tilted water planes, to have drained freely across channels on the

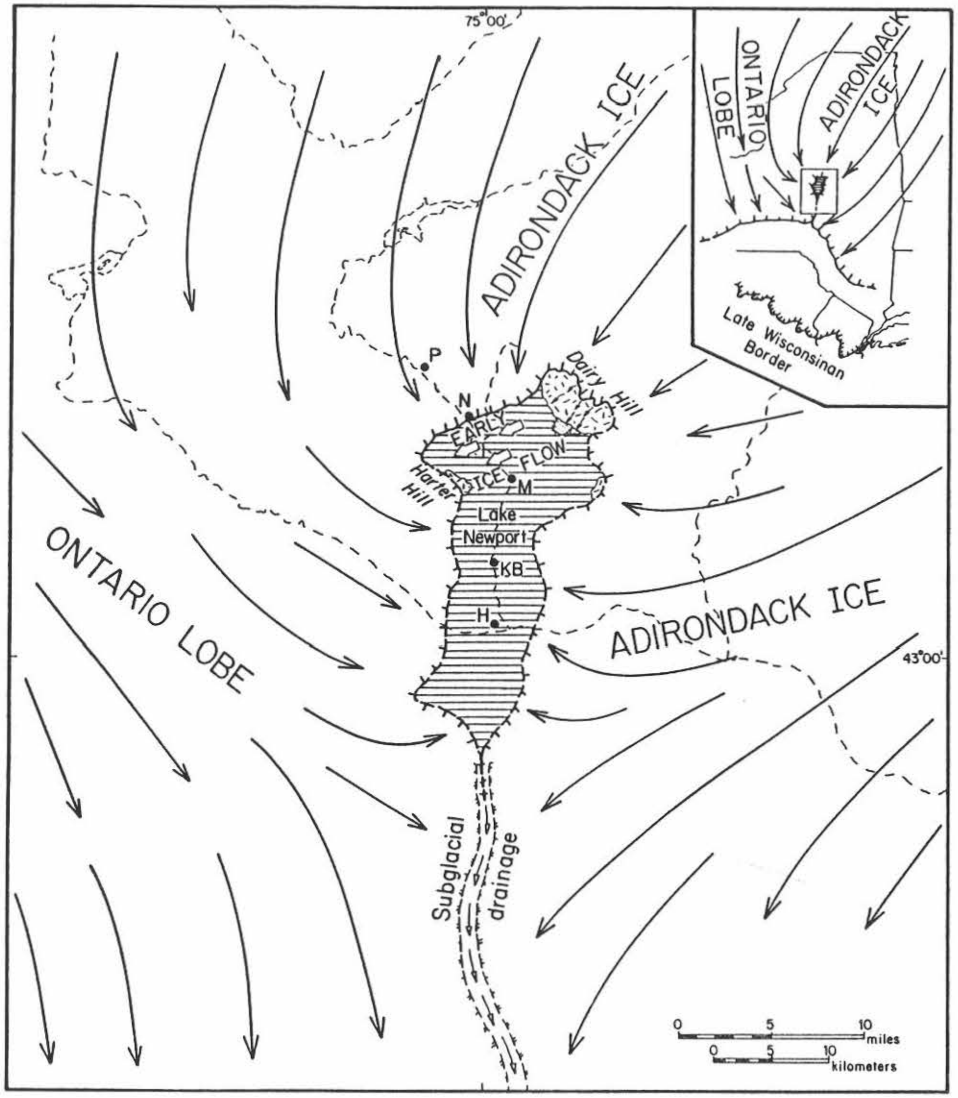


FIGURE 6. Early deglaciation during pre-Valley Heads time and the beginning of Lake Newport.

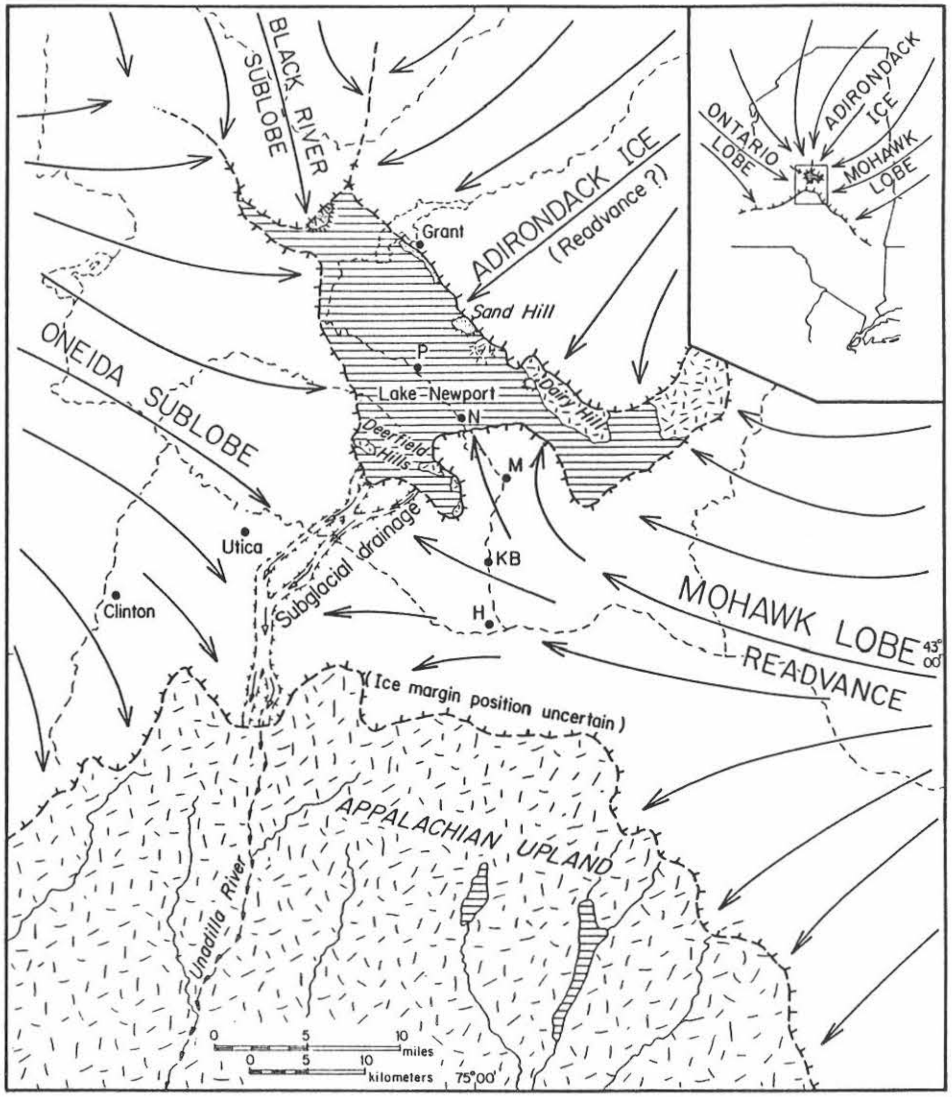


FIGURE 7. The first pre-Valley Heads readvance of the Mohawk Lobe.

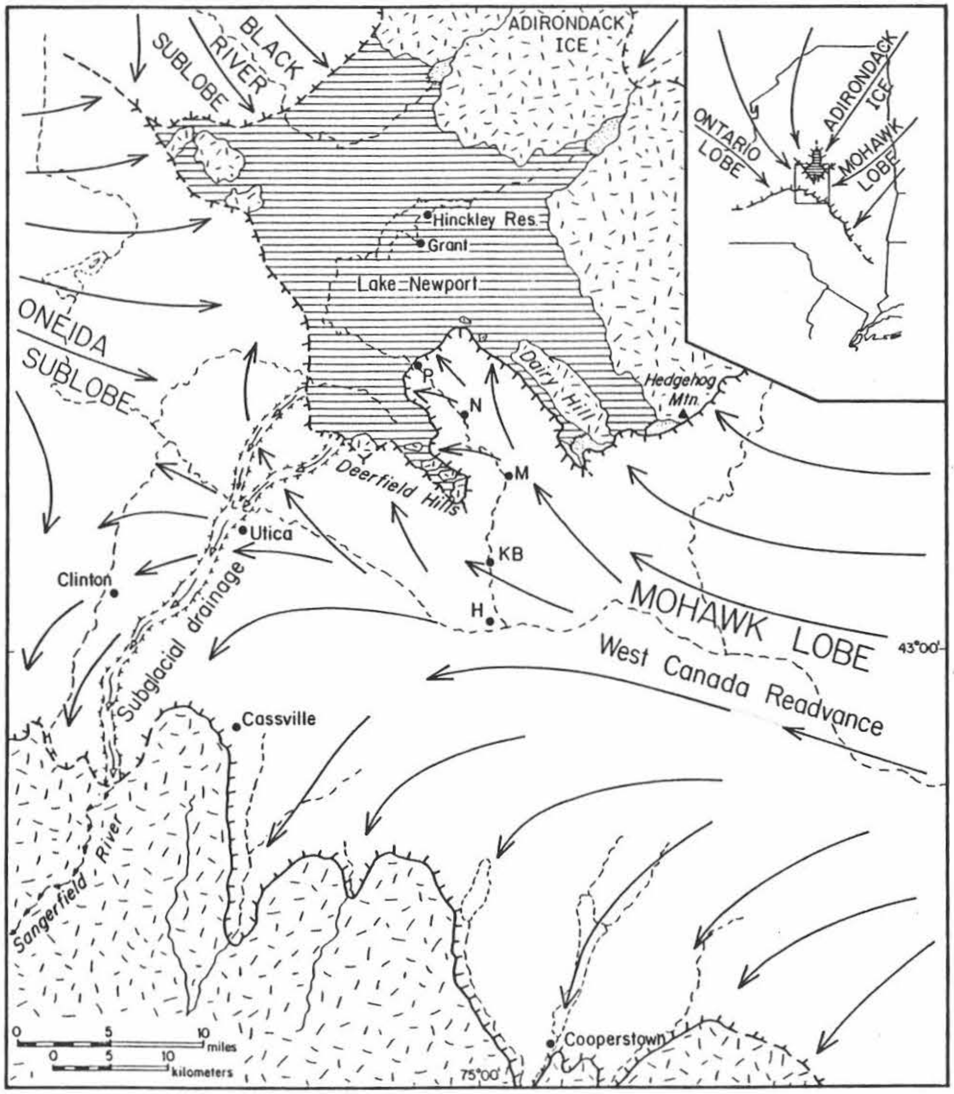


FIGURE 8. The West Canada Readvance.

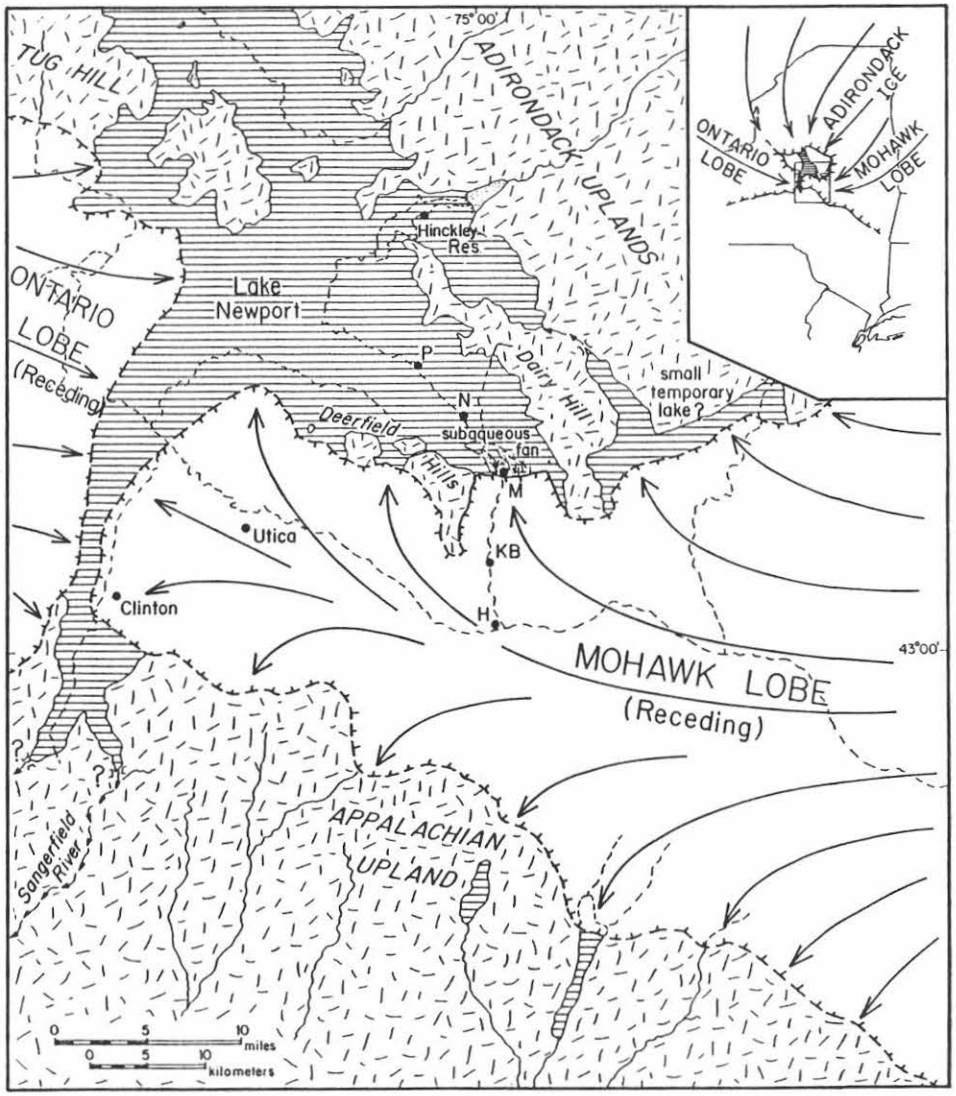


FIGURE 9. Final pre-Valley Heads recession of the Mohawk Lobe.

Appalachian Upland (Figs. 6-8; Ridge and others, 1991). A subglacial, and possibly seasonal or ephemeral, channel system may have drained Lake Newport throughout most of its history.

Two Mohawk Lobe readvances occurred in the West Canada Valley during the history of Lake Newport. The first readvance is thought to be a relatively minor oscillation of the Mohawk Lobe that deposited the West Canada 'A' Diamicton (Figs. 2 and 7; Ridge and others, 1991). This event may be synchronous with the development of a series of ice-marginal subaqueous gravel deposits and a sheet of sandy till that occur across the north flank of Dairy Hill and the upper West Canada Valley, and possibly represent a readvance of Adirondack ice. The later West Canada Readvance represents a major oscillation of the Mohawk Lobe which deposited the West Canada Diamicton. The readvance corresponds to a thick varve sequence which spans the lower and upper Newport Beds exposed in bluffs along the Hinckley Reservoir (Fig. 8; Fullerton, 1971; Franzi, 1984) and deposits that require water levels of at least 463 m (1520 ft) in the West Canada Valley (Fig. 8).

Mohawk Lobe Recession and the Demise of Lake Newport

Final pre-Valley Heads recession of the Mohawk Lobe in Lake Newport left the upper Newport Beds, a thick (up to 40 m) varve and turbidite sequence which is traceable throughout the West Canada Valley (Fig. 2; Ridge and others, 1991). Recession of the Mohawk Lobe triggered a sudden drop in the high levels of Lake Newport, to a lower level which drained freely across the Appalachian Upland (Fig. 9). An esker and subaqueous fan complex in the base of the upper Newport Beds at Middleville may represent this drainage event. Rapid drainage of meltwater from the base of the Mohawk Lobe, in response to dropping lake levels and steepening of subglacial hydraulic gradients, may account for the rapid deposition, great thickness, and lateral extent of the fan complex at Middleville.

Recession of the Mohawk Lobe to the eastern end of the Mohawk Valley eventually caused complete drainage of Lake Newport. This interval of ice recession, which may be an Erie Interstadial equivalent in central New York, is represented by a river gravel in the Mohawk Valley (Little Falls Gravel) and subaerial erosion of the upper Newport Beds in the West Canada Valley (Shed Brook Discontinuity; Figs. 2 and 10; Lykens, 1983; Ridge, 1991).

Early Valley Heads Glaciation and Mohawk Lobe Readvance

At the beginning of Valley Heads glaciation both the Mohawk and Ontario lobes began to advance, eastward river drainage in the Mohawk Valley became blocked by the Mohawk Lobe at the eastern end of the valley, and the Little Falls Gravel and Shed Brook Discontinuity were overlain by lacustrine sediment of the pre-Hawthorne beds (Figs. 2 and 10). Before the Salisbury Readvance of the Mohawk Lobe reached its maximum extent (Fig. 11), lake levels in the Mohawk Valley rose to an elevation of at least 215 m as marked by lacustrine sand in the base of the pre-Hawthorne beds near Poland in the West Canada Valley (Fig. 2).

Valley Heads Impoundment of Lake Cedarville

A sudden change from lacustrine sand to dark gray varves in the pre-Hawthorne beds at about the time the Salisbury Readvance reached its maximum position records a sudden increase in lake level (Figs. 2 and 10). This rise in lake level represents the formation of Lake Cedarville which drained across Cedarville col (369 m, 1210 ft) on the Appalachian Upland into the Unadilla River valley (Fig. 11). The Mohawk Lobe, which advanced into a deepening and widening water body in the Mohawk trough, may have experienced accelerated calving which retarded its advance. The level of Lake Cedarville is recorded at the Salisbury Readvance limit on the north side of the Mohawk Valley by an ice-contact delta (Fig. 11) with an elevation of

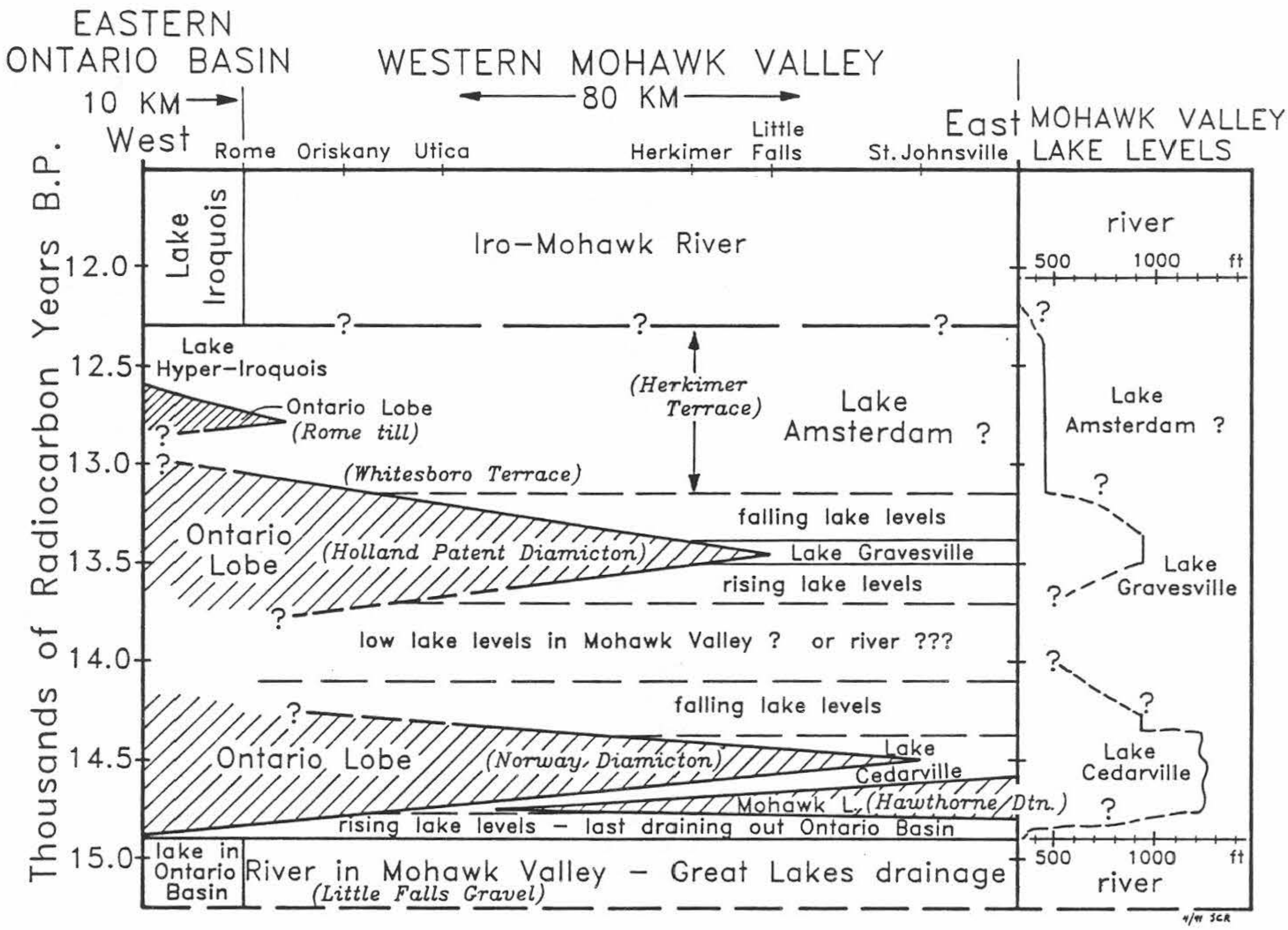


FIGURE 10. Time-distance plot of Valley Heads through post-Valley Heads glacial events in the western Mohawk Valley. Litho- and morphostratigraphic units are shown in italics.

393-396 m (1290-1300 ft). Isostatic tilting of about 0.9 m/km (4.8 ft/mile) accounts for delta elevations which are higher than the Cedarville spillway. Lake Cedarville was formed within 25 years of the Mohawk Lobe attaining its maximum position and during the last several tens of kilometers of advance the Mohawk Lobe did not block off any new outlets that could have caused the impoundment of Lake Cedarville. Therefore, the initial impoundment of Lake Cedarville appears to be the result of the closure of an outlet to the west by the advance of the Ontario Lobe. Outlets to the west (Fig. 5) are today filled with younger deposits of the Valley Heads moraines (Fairchild, 1932; Randall and others, 1988) and would have been lower at the time of the impoundment of Lake Cedarville.

The Maximum Ontario Lobe Readvance into Lake Cedarville

Within 200 years of the Salisbury Readvance the Mohawk Lobe was replaced by the Hinckley-St. Johnsville Readvance of the Ontario Lobe (Figs. 10 and 12; Ridge, 1985; Muller and others, 1986). Initial recession of the Mohawk Lobe allowed deposition of varves of Mohawk Lobe provenance in the post-Hawthorne beds which were overlain by varves of Ontario Lobe provenance in the pre-Norway beds (Fig. 2). The Norway Diamicton was deposited over the varve section as the Ontario Lobe advanced toward the maximum extent of the Hinckley-St. Johnsville Readvance (Fig. 10 and 12). The Ontario Lobe surrounded the Deerfield Hills, creating a nunatak, and Lake Miller

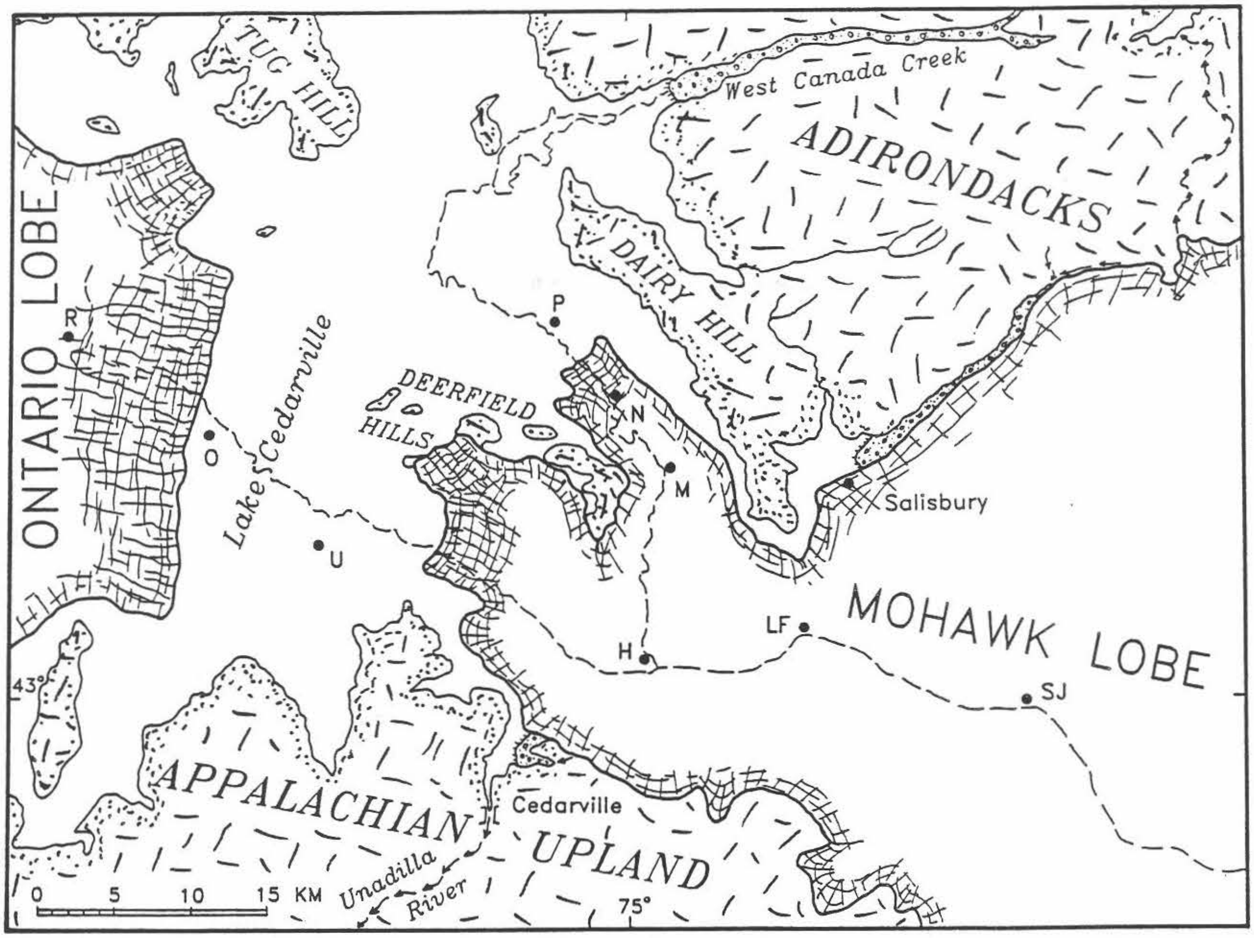
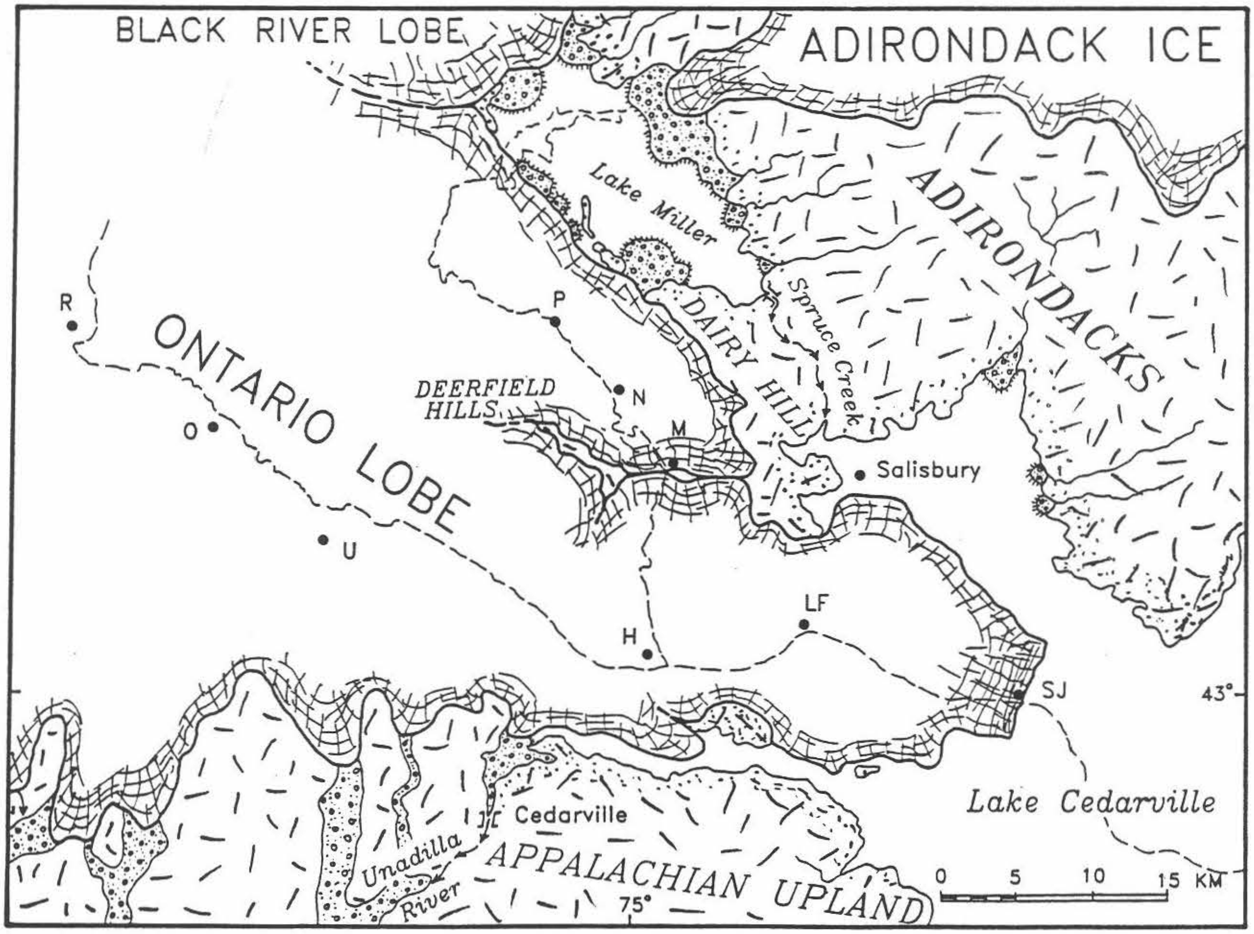


FIGURE 11. The Salisbury Readvance and early Lake Cedarville.

FIGURE 12. The Hinckley-St. Johnsville Readvance and Lake Cedarville.



(Fullerton, 1971; Franzi, 1984) was impounded in the upper West Canada Valley. The position of the Ontario Lobe along the Appalachian Upland is marked by an ice-contact delta near the entrance to the Cedarville channel. The advancing Ontario Lobe probably did not collide with the receding Mohawk Lobe because the Hawthorne and Norway diamictons are separated by lacustrine sediment of the post-Hawthorne and pre-Norway beds throughout the central Mohawk trough.

Recession of the Ontario Lobe is known to have occurred as far west as Oriskany where lacustrine deposits occur beneath the later Holland Patent Diamicton. Early during recession, Lake Miller drained into Lake Cedarville along the northern flank of the Ontario Lobe. Lake Cedarville eventually dropped to a succession of short-lived lake levels in the Mohawk Valley that probably drained across the divide between the Mohawk and Schoharie basins near Charleston Four Corners (302 m, 990 ft; Fig. 5). These events are recorded by large deltas in the upper West Canada Valley that represent Lake Prospect 347-365 m (1120-1200 ft; Franzi, 1984).

The Barneveld-Little Falls Readvance and Glacial Lake Gravesville

The second Valley Heads readvance of the Ontario Lobe, the Barneveld-Little Falls Readvance, deposited the Holland Patent Diamicton (Figs. 2, 10, and 13). This advance was matched by blockage of the eastern Mohawk Valley by the Mohawk Lobe and the creation of a valley-wide lake known as Lake Gravesville. The impoundment of Lake Gravesville appears to closely coincide with the halt of the Barneveld-Little Falls Readvance which may have temporarily stabilized on a bedrock high at Little Falls as water levels rose in front of the Ontario Lobe. Lake Gravesville is marked by the deposition of ice contact deltas along the northern flank of the Ontario Lobe and a delta at the mouth of East Canada Creek (292-310 m, 960-1020 ft; Fig. 13). After consideration of isostatic tilting in the region the most likely stable spillway for Lake Gravesville is Delanson channel at 254 m (835 ft; Fig. 5) which is located on the Schoharie-Hudson divide in eastern New York.

Ontario Lobe Recession and Impoundment of Lake Amsterdam

Lake Gravesville did not persist long after Ontario Lobe recession began because Gravesville deltas in the West Canada Valley are limited to ice-contact features and they do not occur along the southwest side of the valley from Barneveld to Poland where high discharge from the Adirondacks continued to deliver large volumes of sediment. Lake levels dropped as the Mohawk Lobe receded and lower outlets were opened in the southeastern Mohawk Valley, but the exact pattern of lake drainage is not known from evidence in the western Mohawk Valley. Water levels in the Mohawk Valley dropped to a minimum elevation of 171 m (560 ft) by the time the Ontario Lobe receded to just west of Herkimer (Figs. 10 and 14). High fluvial terraces in the West Canada Valley may have formed at this time.

Ontario Lobe recession continued to Oriskany (Figs. 10 and 15) where the Whitesboro Terrace represents the first deposition of ice-contact deposits graded to a water level lower than 152 m (500 ft) in the Mohawk Valley in what is probably the beginning of Lake Amsterdam. The Whitesboro Terrace at first glance appears to be an ice-contact delta, but several exposures in this feature show a cap of fluvial beds truncating lacustrine sand along a regionally tilted contact. The fluvial beds emanate from a kettle and esker complex in the Oriskany Valley and probably represent deposition on a surface trimmed by fluvial erosion in response to falling lake levels in the Mohawk Valley. The Whitesboro Terrace surface as well as inwash deltas further east in the Mohawk Valley may be graded to Lake Amsterdam which had an elevation of 139 m (457 ft) at Herkimer. Recession of the Ontario Lobe continued to Rome while Lake Amsterdam remained impounded in the Mohawk Valley.

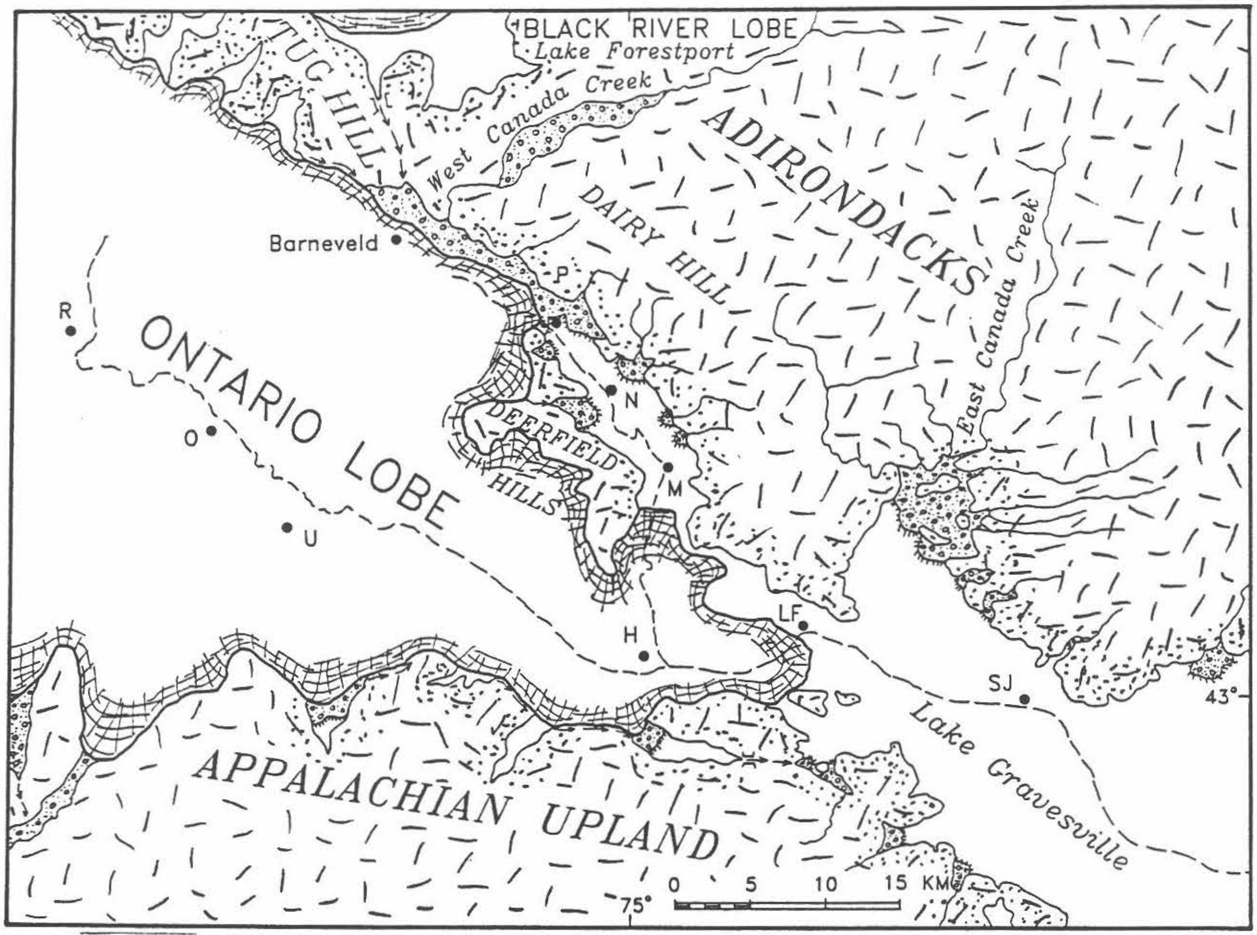
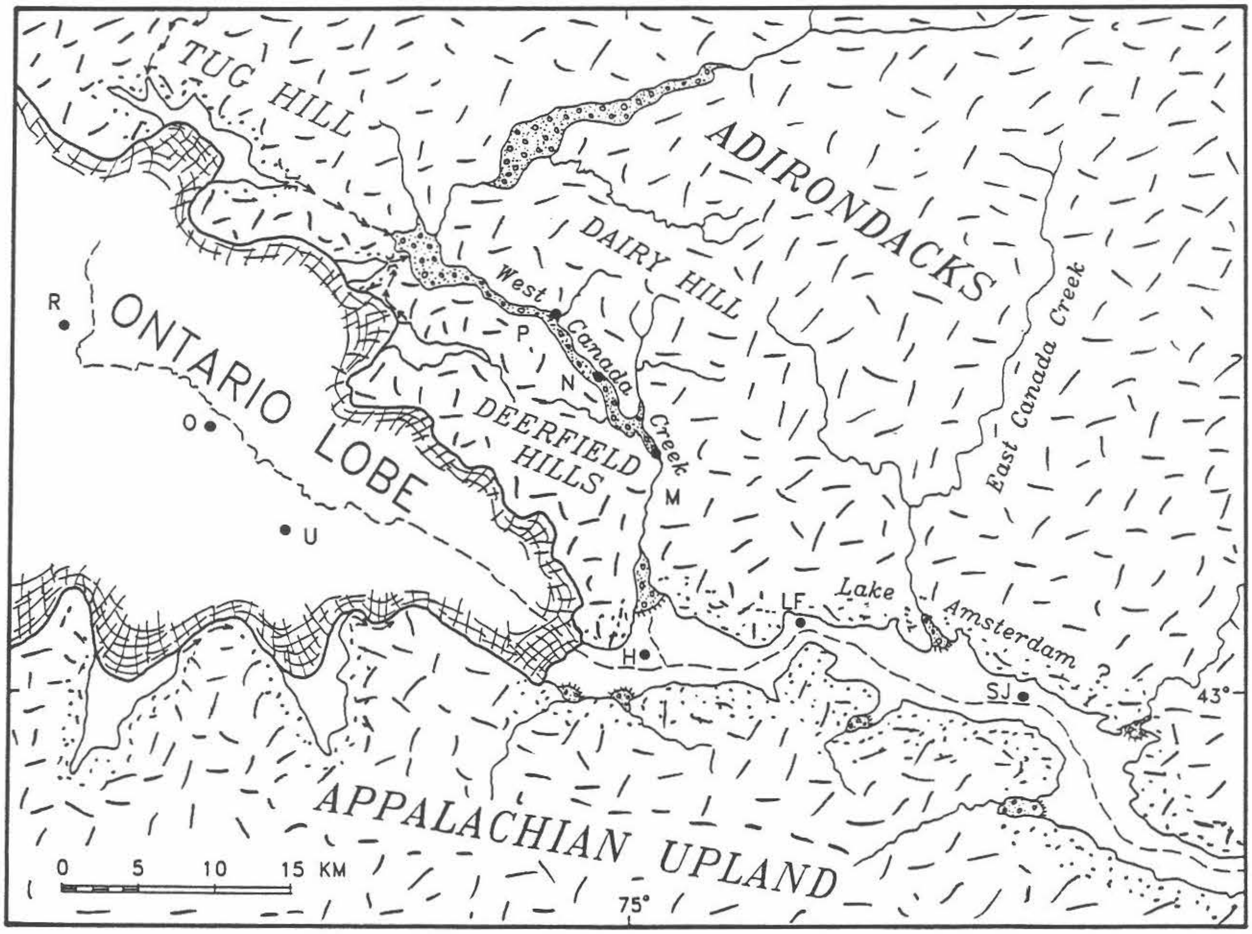


FIGURE 13. The Barneveld-Little Falls Readvance and Lake Gravesville.

FIGURE 14. The final recession of the Ontario Lobe west of Herkimer.



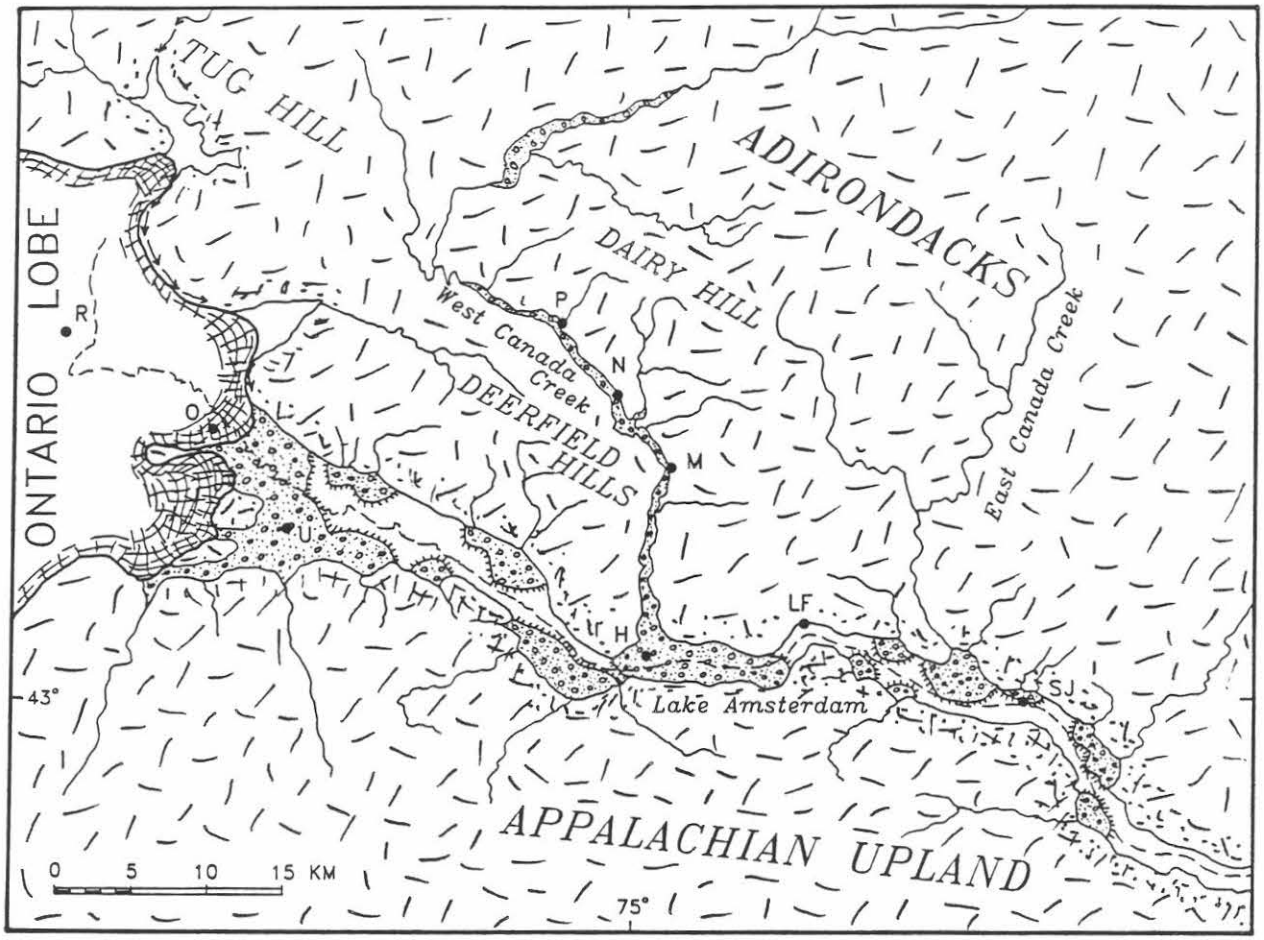
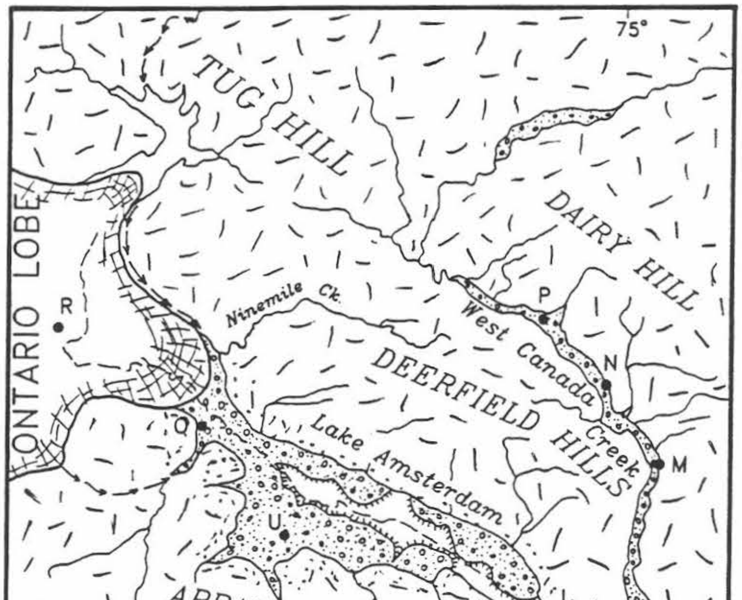


FIGURE 15. Recession of the Ontario Lobe to Oriskany and development of the Whitesboro Terrace in Lake Amsterdam.

FIGURE 16. The Ninemile Readvance and Lake Amsterdam.



Post-Valley Heads Readvance of the Ontario Lobe

The final Late Wisconsinan readvance of the Ontario Lobe into the Mohawk Valley, the Ninemile Readvance, deposited a thin (0.5-2.0 m) red till sheet (Rome till of Muller and others, 1986) on lacustrine sand as far east as Ninemile Creek (Figs. 10 and 16; Loewy, 1983). Deposits and features near Rome, that were used to define the Stanwix Readvance (Fullerton, 1971, 1980) may be the result of the more extensive ice cover of the Ninemile Readvance. A fluvial terrace at the limit of the Ninemile Readvance, which is inset in the Whitesboro Terrace, is probably graded to Lake Amsterdam. Following Ontario Lobe recession, the initial high phase of Lake Iroquois, named Lake Hyper-Iroquois by Fullerton (1971, 1980), may have been a westward extension of Lake Amsterdam. Lake Amsterdam finally drained as Mohawk Lobe recession unplugged the eastern Mohawk Valley allowing free eastward drainage to occur in the Mohawk Valley. Lake Iroquois established a spillway on the Mohawk-Ontario divide at Rome. Lake Iroquois drainage in the western Mohawk Valley (Iro-Mohawk River) is represented by a series of fluvial gravel terraces which can be traced down valley to Schenectady (LaFleur, 1983).

CONCLUSIONS

Several aspects of Late Wisconsinan glaciation in the western Mohawk Valley have broad applications to other areas of New York. In particular, the western Mohawk Valley has well exposed sections of sediment deposited by glaciers which advanced into deep glaciolacustrine troughs. The deposits provide a rare opportunity to study glacial processes and formulate depositional models for this type of environment. The region is especially important because trough environments in many areas are today occupied by modern lakes where core data is difficult to obtain and one must interpret seismic records. Glacial models developed in the western Mohawk Valley may enhance our ability to interpret seismic records.

It is also important to recognize possible glaciological controls imparted by (1) deep lacustrine water (up to 350 m) fronting calving ice margins, (2) the advance of ice lobes into troughs that have varying dimensions, and (3) changing water levels due to lake impoundment or breakout created by oscillating ice lobes. Water depth and trough dimensions in the Mohawk Valley may account for the rapid flow (surging?) and recession of ice lobes, the sudden termination of readvances, and the non synchronous nature of Ontario and Mohawk Lobe readvances on a scale of hundreds of years. Glaciological controls by these parameters have been relatively well studied in glaciomarine settings, but their lacustrine counterparts deserve much more attention because they are likely to be important to understanding the glacial history of lacustrine ice margins across much of the northeastern United States and Great Lakes region.

REFERENCES

Brennan, W.J., Hamilton, M., Kilbury, R., Reeves, R.L., and Covert, L., 1984, Late Quaternary secular variation of geomagnetic directions in western New York: Earth and Planetary Science Letters, v.70, p.363-372.

Brigham, A.P., 1898, Topography and deposits of the Mohawk Valley: Geological Society of America Bulletin, v.9, p.183-210.

_____, 1908, Fourth report of the director [Mohawk Valley]: New York State Museum Bulletin, v.121, p.21-31.

_____, 1911, Mohawk glacial lobe [abs. with discussion]: Geological Society of America Bulletin, v.22, p.725-726.

_____, 1929, Glacial geology and geographic conditions of the lower Mohawk Valley: New York State Museum Bulletin, v.280, 133 p.

Chamberlin, T.C., 1883, Preliminary paper on the Terminal Moraine of the second glacial epoch: U.S. Geological Survey Annual Report no.3, p.291-402.

_____, 1888, The rock-scourings of the great ice invasions: U.S. Geological Survey Annual Report no.7, p.147-248.

Cotter, J.F.P., Ridge, J.C., Evenson, E.B., Sevon, W.D., Sirkin, L. and Stuckenrath, R., 1986, The Wisconsinan history of the Great Valley, Pennsylvania and New Jersey, and the age of the "Terminal Moraine," in Cadwell, D.S. (ed.), The Wisconsinan Stage of the First Geological District, eastern New York: New York State Museum Bulletin no. 455, p.22-49.

Crowl, G.H., 1980, Woodfordian age of the Wisconsin glacial border in northeastern Pennsylvania: Geology, v.8, p.51-55.

_____ and Sevon, W.D., 1980, Glacial border deposits of late Wisconsinan age in northeastern Pennsylvania: Pennsylvania Geological Survey, 4th ser., General Geology Report G-71, 68 p.

Cushing, H.P., 1905, Geology of the vicinity of Little Falls, Herkimer County: New York State Museum Bulletin, v.77, 95 p.

Dana, J.D., 1863, On the existence of a Mohawk Valley glacier in the glacial epoch: American Journal of Science, v.35, p.243-249.

Fairchild, H.L., 1912, Glacial waters in the Black and Mohawk Valleys: New York State Museum Bulletin, v.160, 47 p.

_____, 1916, Pleistocene uplift of New York and adjacent territory: Geological Society of America Bulletin, v.27, p.235-262.

_____, 1917, Postglacial uplift of northeastern North America: Geological Society of America Bulletin, v.29, p.187-238.

_____, 1932, New York moraines: Geological Society of America Bulletin, v.41, p.627-662.

Frakes, L.A., 1978, Diamictite, in Fairbridge, R.W. and Bourgeois, J. (eds.), The encyclopedia of sedimentology: Stroudsburg, Pennsylvania, Dowden, Hutchinson and Ross, p.262-263.

Franzi, D.A., 1984, The glacial geology of the Remsen-Ohio region, east-central New York: [Ph.D. dissert.]: Syracuse, New York, Syracuse University, 172 p.

Fullerton, D.S., 1971, The Indian Castle glacial readvance in the Mohawk Lowland, New York and its regional implications: [Ph.D. dissert.] Princeton, New Jersey, Princeton University, 270 p.

_____, 1980, Preliminary correlation of post-Erie Interstadial events (16,000-10,000 radiocarbon years before present), central and eastern Great Lakes region, and Hudson, Champlain, and St. Lawrence Lowlands, United States and Canada: U.S. Geological Survey, Professional Paper 1089, 52 p.

Johnson, E.A., Murphy, T., and Torreson, O.W., 1948, Pre-history of the earth's magnetic field: Terrestrial Magnetism and Atmospheric Electricity (now Journal of Geophysical Research): v.53, p.349-372.

Koteff, C. and Larsen, F.D., 1989, Postglacial uplift in western New England: Geologic evidence for delayed rebound, in Gregersen, S. and Basham, P.W. (eds.), Earthquakes in North-Atlantic passive margins: Neotectonics and postglacial rebound: Norwell, Massachusetts, Kluwer Academic Publishers, p.105-123.

Krall, D.H., 1977, Late Wisconsinan ice recession in east-central New York: Geological Society of America Bulletin, v.88, p.1679-1710.

LaFleur, R.G., 1983, Mohawk Valley episodic discharges - the geomorphic and glacial sedimentary record, in Friedman, G.M., (ed.), Guidebook for Field Trips: National Association of Geology Teachers, Eastern Section, Annual Spring Meeting, p.45-68.

Lewis, H.C., 1884, Report on the terminal moraine in Pennsylvania and western New York: Pennsylvania Geological Survey Report Z, 299 p.

Loewy, J.M., 1983, The Pleistocene geology of the Oriskany, New York 7.5-minute quadrangle: [M.S. thesis] Syracuse, New York, Syracuse University, 67 p.

Lykens, C., 1983, Delineating the maximum extent of the Oneida Lobe in the Mohawk Valley: [M.S. thesis], Syracuse, New York, Syracuse University, 84 p.

Mickelson, D.M., Clayton, L., Fullerton, D.S., and Borns, H.W., Jr., 1983, The late Wisconsin glacial record of the Laurentide ice sheet in the United States, in Porter, S.C. (ed.), The late Pleistocene, Volume 1 of Wright, H.E., Jr. (ed.), Late Quaternary environments of the United States: Minneapolis, Minnesota, University of Minnesota Press, p.3-37.

Miller, W.J., 1909, Ice movement and erosion along the southwestern Adirondacks: American Journal of Science, v.27, p.289-298.

Muller, E.H., Franzi, D.A., and Ridge, J.C., 1986, Pleistocene geology of the western Mohawk Valley, New York, in Cadwell, D.H. (ed.), The Wisconsinan Stage of the First Geological District, eastern New York: New York State Museum Bulletin no. 455, p.143-157.

____ and Prest, V.K., 1985, Glacial lakes in the Ontario Basin, in Karrow, P.F. and Calkin, P.E. (eds.), Quaternary evolution of the Great Lakes: Geological Association of Canada, Special Paper 30, p.212-229.

Ovenshine, A.T., 1970, Observations of iceberg rafting in Glacier Bay, Alaska, and the identification of ancient ice-rafted deposits: Geological Society of America Bulletin, v.81, p.891-894.

Pair, D., 1986, Reconstruction and history of ice retreat, proglacial lakes, and the Champlain Sea, central St. Lawrence Lowlands, New York: [M.Sc. thesis]: Waterloo, Ontario, University of Waterloo, 204 p.

____, Karrow, P.F., and Clark, P.U., 1988, History of the Champlain Sea in the central St. Lawrence Lowland, New York, and its relationship to water levels in the Ontario basin, in Gadd, N.R. (ed.), The Late Quaternary development of the Champlain Sea basin: Geological Association of Canada, Special Paper 35, p.107-124.

Randall, A.D., Snavely, D.S., Holecek, T.J., and Waller, R.M., 1988, Alternative sources of large seasonal ground-water supplies in the headwaters of the Susquehanna River basin, New York: U.S. Geological Survey Water-Resources Investigation report 85-4127, 121 p.

Ridge, J.C., 1985, The Quaternary glacial and paleomagnetic record of the West Canada Creek and western Mohawk Valleys of central New York: [Ph.D. dissert.] Syracuse, New York, Syracuse University, 471 p.

____, 1991, The Shed Brook Discontinuity and Little Falls Gravel, possible Erie Interstade equivalents in central New York in Ridge, J.C. (ed.), Late Wisconsinan glaciation of the western Mohawk and West Canada Valleys of central New York: Medford, Massachusetts, Tufts University, Friends of the Pleistocene, 54th Annual Reunion, p.D1-D19.

____ and Larsen, F.D., 1990, Re-evaluation of Antevs' New England varve chronology and new radiocarbon dates of sediments from glacial Lake Hitchcock: Geological Society of America Bulletin, v.102, p.889-899.

____, Brennan, W.J., and Muller, E.H., 1990, The use of paleomagnetic declination to test correlations of late Wisconsinan glaciolacustrine sediments in central New York: Geological Society of America Bulletin: v.102, p.26-44.

____, Franzi, D.A., and Muller, E.H., 1991, Late Wisconsinan, pre-Valley Heads glaciation in the western Mohawk Valley, central New York and its regional implications: Geological Society of America Bulletin, v.103, p.1032-1048.

Verosub, K.L., 1979, Paleomagnetism of varved sediments from western New England: secular variation: Geophysical Research Letters, v.6, p.245-248.

ROAD LOG

Please have one person in each vehicle follow the road log to avoid getting lost and separated. Figure references are to those in the guidebook article, except Figure 17 which is from Ridge and others, 1990 and will be handed out separately at the beginning of the trip. All route descriptions and place names are given as shown on NYS Dept. of Transportation 7.5-minute topo maps which are culturally updated versions of USGS topos.

Be prepared for muddy and steep outcrops. A small pick or shovel and a knife for cutting clay are recommended. Two small stream crossings will be necessary depending on weather conditions.

Assembly Point and Departure: Colgate University, Hamilton, NY **8:00 A.M. sharp!**

The road log begins at the intersection of Rt.51 North and Rt.20 in the town of East Winfield or Birmingham Corners. To reach Rt.20 head north from Hamilton on Rt.12B. Take Rt.20 east to East Winfield.

Mileage	Route Description
0.0 (0.0)	From Rt.20 in East Winfield head north on Rt.51 toward Cedarville.

1.8 (1.8) Crossroads in Chepachet. Swampy lowland to the west is the channel leading south from Cedarville col.

3.0 (1.2) Pull over to the right side of Rt. 51.

STOP 1: **Overview of Cedarville col** (1210 ft) which is on the divide between the Unadilla River (Susquehanna Basin) and Steele Creek (Mohawk Basin) drainages. Cedarville col served as the outlet for Lake Cedarville, a high level Valley Heads lake in the Mohawk Valley (Figs. 5 and 10-12).

3.35 (0.35) Continue north on Rt.51. Turn left (west) in Cedarville to stay on Rt.51.

3.5 (0.15) Turn right to stay on Rt.51 which heads northeast into the valley of Steele Ck. Steele Ck. descends into Ilion Gorge which exposes much of the late Ordovician through Silurian stratigraphy of the western Mohawk Valley. Red shale exposed in the gorge is the Vernon Shale which is the source of the red color in glacial units of the region. A large inwash delta at the mouth of Steele Ck. in the Mohawk Valley indicates that Ilion Gorge was largely cut during the late Pleistocene existence of Lake Amsterdam.

10.5 (7.0) Rt.51 is joined by Bell Hill Rd. from the south as it enters Ilion. Follow Rt.51 into downtown Ilion.

12.1 (1.6) Traffic light in Ilion. Continue straight on Rt. 51.

12.5 (0.4) Rt.51 crosses the NYS Barge Canal and ends. Take Rt.5 East toward Herkimer. The trip will head through Herkimer where it will pick up Rt.28 North. Because of traffic lights in Herkimer the caravan will be reassembled on Rt.28 North after it splits away from Rt.5.

14.7 (2.2) First traffic light in Herkimer. Continue on Rt.5 East and watch for signs for Rt.28 North.

15.5 (0.8) Turn left (north) on the east side of Herkimer to follow Rt.28 north. Rt.28 follows the West Canada Creek valley.

18.6 (3.1) Town of Kast Bridge. In the next mile, bluff section 828 (Fig. 17) will be visible across W. Canada Ck. The flat top of the bluff to the east is the surface of the Holland Patent Diamicton and silt and clay of the post-Holland Patent beds (Figs. 2 and 13).

22.8 (4.2) Entering town of Middleville, KOA campground ahead on right. Across W.Canada Ck. from campground is bluff section 811 (Fig. 17).

23.8 (1.0) Rt.28 makes an abrupt right turn in Middleville. After turning right, make an immediate left onto Fishing Rock Rd.

24.2 (0.35) Pull over to the side of Fishing Rock Rd.

STOP 2: **Fishing Rock Rd. bluff**, section 324 (Fig. 17). This section has Precambrian gneiss at road level with two striation directions overlain by thin, discontinuous till in the West Canada Diamicton. The diamicton is overlain by sand and gravel and mass flow diamicton beds of an esker/subaqueous fan complex in the base of the upper Newport Beds. Fan deposition at this location may have been triggered by the lowering of Lake Newport at the close of pre-Valley Heads glaciation (Figs. 2 and 9).

24.55 (0.35) Retrace route back to Rt.28 and make a left onto Rt.28.

24.65 (0.1) After crossing W. Canada Ck. into the center of Middleville, turn left at the traffic light, following Rt.28 toward Newport.

27.0 (2.35) West Canada High School. The school sits on fluvial terraces graded to Lake Amsterdam or its immediate predecessor in the Mohawk Valley.

27.3 (0.3) Rt.28 crosses over White Creek.

27.6 (0.3) Rt.28 follows a bend in W. Canada Ck. Bluff section 451 (Fig. 17) is the embankment to the right.

28.0 (0.4) Pull off of Rt.28 on right taking advantage of the old highway pavement. Walk 0.1 mile north along side of Rt.28 to horse pasture and cross cutoff meander loop to bluff along east side of valley.

<u>STOP 3</u>: **Newport bluff,** section 447 (Fig. 17). This bluff exposes the top of the pre-Valley Heads section (Middleville Fm.) which is overlain by the Valley Heads section (Poland Fm.). The two units are separated by the Shed Brook Discontinuity at this exposure (Fig. 2).

29.1 (1.1) Continue north on Rt.28 after arriving in the center of Newport.

29.5 (0.4) In the north end of Newport, turn right onto Gage Rd. The octagonal limestone house at this corner is the workshop site of Linus Yale, inventor of the Yale Lock.

31.0 (1.5) Gage Rd. climbs to the top of a hill composed of the entire glacial section of the W. Canada Valley (Fig. 2). Turn right onto White Creek Rd.

31.2 (0.2) Turn left onto the Newport-Gray Rd. which crosses over White Ck. and enters the Factory Brook valley. About 0.2 miles beyond the White Ck. bridge pull over to the right side of the road by a cow pasture gate.

<u>STOP 4</u>: **Factory Brook bluffs,** sections 225-226 (Fig. 17). The bluff sections across Factory Bk. contain almost the entire pre-Valley Heads section (Fig. 2). The top of till in the West Canada Diamicton at this exposure shows subglacial grooving that records Mohawk Lobe ice flow to the northwest. The top of pre-Valley Heads deposits (upper Newport Beds) are subglacially deformed beneath Valley Heads till in the Norway Diamicton, an Ontario Lobe deposit from the Hinckley-St. Johnsville Readvance (Figs. 10 and 12).

33.3 (1.9) Retrace route back to Gage Rd. and Newport. Take Rt.28 north in Newport toward Poland.

36.8 (3.5) Follow Rt.28 north to the center of Poland. Continue north on Rt.28.

37.3 (0.5) Pull over to right at gravel pit entrance at north end of Poland. Follow dirt road into pit.

STOP 5: **Poland clay pit**, section 338 (Fig. 17). This section exposes lacustrine sediments in the lower part of the Valley Heads Poland Fm. Two important transitions occur in this section. A sudden change from lacustrine sand to dark gray silt and clay varves in the pre- and post-Hawthorne beds marks rising water levels during the initial impoundment of Lake Cedarville. A transition higher in the section from dark gray varves, with only gray ice-rafted pellets (post-Hawthorne beds), to pinkish gray varves, with red and gray ice-rafted pellets (pre-Norway beds), represents the transition from Mohawk to Ontario provenance that occurred between the Salisbury and Hinckley-St. Johnsville readvances. The pre-Norway beds are subglacially deformed beneath till in the Norway Diamicton.

37.8 (0.5) Retrace route back to center of Poland and turn left onto Rt.8 North.

39.5 (1.7) In the center of Cold Brook, continue north on Rt. 8.

42.1 (2.6) Rt.8 North enters the breakout channel of Lake Miller as it passes by Hurricane Rd. Continue north on Rt.8.

43.2 (1.1) Turn right off of Rt.8 onto Hall Rd.

43.7 (0.5) After Hall Rd. climbs to top of hill, turn left onto Burt Rd. and pull over to right.

STOP 6: **Lake Miller delta** at the maximum position of the Hinckley-St. Johnsville Readvance (Valley Heads, Ontario Lobe, Figs. 10 and 12). Burt Rd. crosses the distal part of the delta which is graded to a water level of 1410 ft that drained across a spillway into Spruce Creek. Map analysis of delta and spillway elevations in the upper West Canada Valley from this stage of Lake Miller indicates that isostatic tilting in the region was about 4-5 ft/mile. When the Ontario Lobe began to recede, Lake Miller drained southward across the delta by way of the breakout channel along Rt. 8 which served as the spillway for a second stage of Lake Miller at about 1390 ft.

44.5 (0.8) Follow Burt Rd. north to Rt.8. Take Rt.8 North.

45.85 (1.35) Continue north on Rt.8 as it crosses Black Creek.

47.85 (2.0) Turn left off of Rt.8 onto Ash Creek Rd. toward Ohio. Ash Creek Rd. will become Pardeeville-Ohio Rd.

50.7 (2.85) Pass through Ohio on Pardeeville-Ohio Rd. and cross over Reese Rd. The next several miles of the trip will cross areas of the Ohio sand plain which represents deposition of deltaic and lake-bottom sand in Lake Miller. Sand in this area sits on clay and silt of the Newport Beds (pre-Valley Heads).

51.8 (1.1) Turn right off of Pardeeville-Ohio Rd. onto Smith Rd.

52.7 (0.9) Turn left off of Smith Rd. onto Dow Rd.

53.6 (0.9) Intersection where Dow Rd. turns sharply to the left and becomes Hemstreet Rd. THIS AREA IS PRIVATE PROPERTY! Continue straight off of Dow Rd. on dirt path toward the Hinckley Reservoir. Access to the reservoir will depend on water levels.

STOP 7: **South shore bluffs of the Hinckley Reservoir.** The bluffs expose the lower through upper Newport Beds, deposited in Lake Newport during the time of the West Canada Readvance which was confined to the lower W. Canada Valley (Figs. 7-9). Readvance activity of the Mohawk Lobe is marked by provenance changes in varves at the Hinckley bluffs. Varves at the base of the section are sandy, have an Adirondack source, and overlie a very sandy and bouldery Adirondack diamicton. The sandy varves give way to clayey dark gray varves of Mohawk Lobe provenance. Mohawk Lobe varves are then overlain by Adirondack varves marking the recession of the Mohawk Lobe and dropping water levels in Lake Newport. The Hinckley bluffs also have spectacular slump and load structures.

54.5 (0.9) Return to Hemstreet Rd. and follow it south to a T with Hill Rd. Turn right (west) onto Hill Rd. and follow it toward Grant. Hill Rd. will turn into Stormy Rd.

56.5 (2.0) After crossing over Black Ck. in Grant, turn right onto Southside Rd. and follow it to the Hinckley Reservoir dam and Rt.365.

60.6 (4.1) Turn left onto Rt.365 toward Barneveld after crossing W. Canada Ck.

61.0 (0.4) Town of Hinckley. The bluff tops across W. Canada Ck. to the south are ice-contact deltas built along the receding margin of the Ontario Lobe (Hinckley-St. Johnsville Readvance, Figs. 10 and 12). The deltas are graded to the second stage of Lake Miller which drained through the channel seen along Rt.8 near Stop 6.

62.5 (1.5) Continue west on Rt.365 north of the town of Prospect. Prospect sits on the surface of a delta built into Lake Prospect (Franzi, 1984) which formed for a short time during the drainage of Lake Cedarville in the Mohawk and W. Canada valleys.

64.7 (2.2) Immediately after crossing under the Conrail railroad bridge turn left onto Parker Hollow Rd. which follows Cincinnati Ck.

65.1 (0.4) Pull over to the right side of Parker Hollow Rd.

STOP 8: **Bluffs on Cincinnati Ck.** expose later Valley Heads deposits in the upper W. Canada Valley. The base of the section is esker/subaqueous sand and gravel overlain by varves with red ice-rafted pellets (post-Norway beds). Till in the Holland Patent Diamicton overlies the post-Norway beds and it is overlain by an ice-contact delta of Lake Gravesville (Figs. 10 and 13). This locality is just inside the eastern limit of the Barneveld-Little Falls Readv. of the Ontario Lobe.

66.4 (0.7) Continue southwest on Parker Hollow Rd., under the Rt.12-28 highway bridge to a stop sign in Barneveld. Continue straight across the intersection onto Rt.365 West.

70.3 (3.9) Center of Holland Patent, continue west on Rt.365. Watch for signs for Floyd.

75.2 (4.9) Center of Floyd. Turn left (south) off of Rt.365 onto Koenig Rd. toward Oriskany.

77.4 (2.2) At end of Koenig Rd. turn right (west) onto River Rd.

77.55 (0.15) Pull off to right onto dirt road at sand pit.

STOP 9: **River Rd. sand pit.** This section is representative of exposures in the broad undulating plain between Rome to the west and Ninemile Ck. to the east. It provides evidence for the final readvance (post-Valley Heads) of the Ontario Lobe into the Mohawk Valley (Ninemile Readvance, Figs. 10 and 16). The section has 0.5-2.0 m of red till (Rome till of Muller and others, 1986) overlying about 10-15 m of lacustrine sand that was deposited in Lake Amsterdam. The sand is subtly deformed at the base of the till which does not occur east of Ninemile Ck.

78.3	(0.6)	Retrace route east and continue on River Rd. to bridge over Ninemile Ck. Continue east on River Rd.
78.8	(0.5)	After crossing small unnamed stream valley, branch off to south away from River Rd.
79.1	(0.3)	You will encounter a complex intersection with a series of stop signs. DO NOT get on Rt.49. Stay to the left and follow signs to Oriskany.
79.7	(0.6)	Cross over the Mohawk River bridge.
80.4	(0.7)	After crossing the Mohawk River flood plain, turn left onto Rt.69 East in Oriskany.
81.1	(0.7)	Pass by landfill entrance on right. Hill top to right is the Whitesboro Terrace. Continue east on Rt.69.
82.2	(1.1)	At entrance to Burrows Hauling Co. follow dirt road to back of large sand and gravel pit.

STOP 10: The pit shows the interior of the **Whitesboro Terrace** which is an esker-fed, ice-contact feature formed at a recessional position of the Ontario Lobe during the last gasp of Valley Heads glaciation (Figs. 10 and 15). The terrace appears to be an ice-contact delta because it has 5-10 m of fluvial gravel capping lacustrine sand along what resembles a deltaic topset/foreset contact. However, the contact does not represent a horizontal surface and is tilted regionally down to the east-northeast. The gravel was deposited on a fluvially scoured surface that probably represents trimming of the sand (delta or subaqueous fan?) in response to falling lake levels in the Mohawk Valley. The gravel cap represents the first Ontario Lobe, ice-contact deposit graded to a water level less than 500 ft in the western Mohawk Valley (Lake Amsterdam). Further east in the western Mohawk Valley Lake Amsterdam is only recorded by inwash deltas.

END OF MILEAGE LOG: At this point we will try to return to Hamilton as quickly as possible following the directions below:

- Continue southeast on Rt. 69 for 2 miles to where it turns into Rt.5A. Follow Rt.5A southwest for 3 miles to Rt.5. Turn right (west) onto Rt.5 for 0.15 miles. Turn left (southwest) onto Rt.5B for 1.4 miles. Take Rt.12B southwest for 14 miles through Clinton and Oriskany Falls to Rt.20. Take combined Rts. 20 and 12B west for 3 miles through Madison to where Rt.12B splits to the south. Take Rt.12B south for 6 miles to Hamilton.