The Late Wisconsinan Glaciation of the West Canada Creek Valley

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INTRODUCTION

This field trip focuses on the glacial stratigraphy of the West Canada Valley and the interpretation of the Late Wisconsinan history of the region. The Late Wisconsinan stratigraphic record in the West Canada Creek Valley (Figure 1) is unique in central New York in terms of its completeness and in the complexity of the glacial events that it represents. The significance of such lithostratigraphic documentation of the glacial record is underscored by the lack of success in developing a regional glacial chronology based on morphostratigraphic relationships (Coates, 1976; Calkin and others, 1982). Correlations based solely on morphologic evidence are often ambiguous due to the time transgressive and composite nature of many glacial landforms. The glacial deposits of the West Canada Creek Valley provide an important lithostratigraphic basis for correlations to the well-developed time-stratigraphic and geologic-climate classifications in the eastern Great Lakes Region (Dreimanis and Karrow, 1972; Dreimanis and Goldthwait, 1973).

The West Canada Creek Valley is an area where the sedimentology of readvance deposits and relative chronology of simultaneous readvances from several different ice flow directions may be studied. Ice from the Ontario Lobe (Black River and Oneida Sublobes) and the Hudson-Champlain Lobe (Mohawk Sublobe) as well as Adirondack through flow and possible Adirondack ice cap sources encroached on this region during the Late Wisconsinan (inset on Figure 1).

The field trip is designed to give an introduction to as many of the glacial stratigraphic units as possible and to show their sedimentologic diversity. It can in no way, however, show all the stratigraphic relationships which were used to determine the glacial history of the region. This would require too many stops for a one day excursion. In addition, many exposures that would be more informative than those shown on this trip are not readily accessible or are inappropriate for a group of this size. Important localities which are not included as stops on the field trip are discussed in

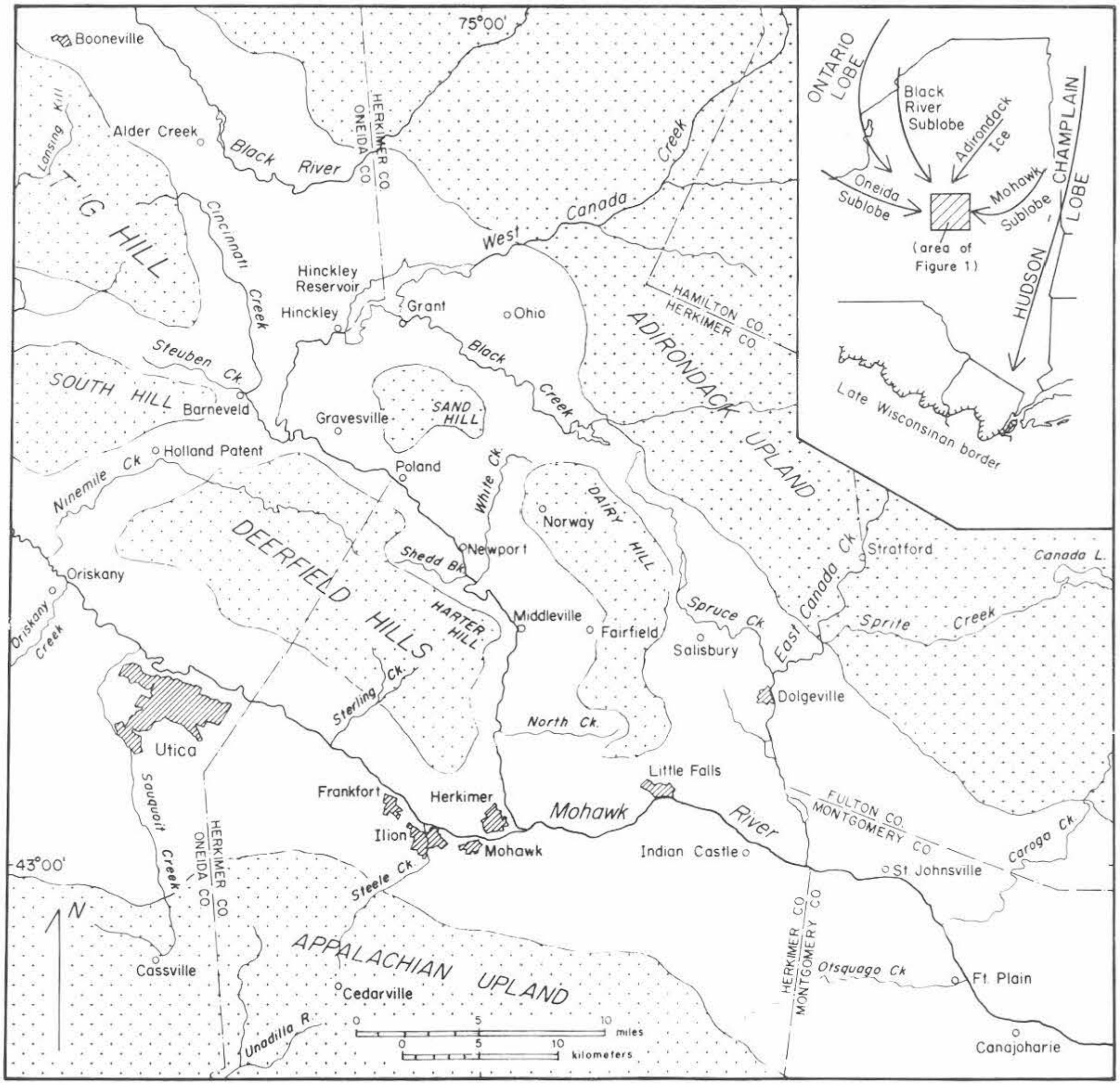


Figure 1. -- Location map of the West Canada Creek Valley and surrounding regions. Upland areas are patterned. This map serves as a base map for Figures 8, 9 and 11 thru 13. Inset map shows general flow direction of glacial lobes and sublobes that affected the region during Late Wisconsinan time and the maximum extent of Late Wisconsinan glaciation.

the text.

PREVIOUS WORKS

Even prior to the acceptance of the Glacial Theory, glacial features were recognized in the Mohawk Valley by Vanuxem (1842). The existence of a "Mohawk Valley glacier", which flowed from east to west in the Mohawk Valley, was first proposed by Dana (1863). Chamberlin (1883, 1888) cited striation evidence in support of a Mohawk Lobe moving eastward in the valley and this idea was later amplified by Brigham (1898, 1908). Chamberlin (1883) first recognized that the Adirondack Upland impeded ice flow and forced lobation of the ice-front into adjacent valleys. Miller (1909) reached a similar conclusion from his studies of ice movement and glacial erosion in the Black River Lowland. Brigham (1898) provided well-log data for deposits along the western Mohawk River and described morphologic features while Cushing (1905) provided brief descriptions of deposits in the Little Falls area. It was generally agreed that while the Mohawk Lobe showed evidence of having been active during advance, the area was probably deglaciated by downwasting and overall stagnation, a behavior that was responsible for thin drift on the valley sides and a conspicuous lack of morainic features (Brigham, 1911, 1929). Fairchild (1912) speculated on valley-wide ice-dammed lakes which extended into the Black River Lowland. These lakes drained across the Appalachian Plateau and were ponded by the receding Ontario and Hudson-Champlain ice masses. Brigham (1911, 1929) was critical of the lake chronology proposed by Fairchild. He recognized meltwater impoundment as playing a major role in the deglaciation of the Mohawk Valley at lower elevations (less than 200 m) but he saw no evidence for widespread lacustrine deposits at higher elevations (200 to 400 m) which should have existed if the proglacial lakes drained into the through-valley system of the Appalachian Upland.

Fullerton (1971) and Krall (1977) were the first to present stratigraphic evidence for large-scale readvances that occurred in the western Mohawk Valley region. Fullerton (1971) studied deposits near the eastern-most margin of the Ontario Lobe (Oneida Sublobe) in the Mohawk Valley. Some of the sections that he described are included on this field trip. Fullerton named the expansion of Ontarian ice the "Indian Castle Readvance" and correlated deposits of this readvance and the Valley Heads Moraines of central New York. Older deposits, some of eastern provenance (Mohawk Sublobe), were described in stratigraphic sections but Fullerton did not formulate a comprehensive glacial history for the pre-Indian Castle events.

Krall (1977) traced the Cassville-Cooperstown Moraine of the Mohawk Sublobe along the Appalachian Plateau from Cooperstown to Cassville where it is truncated by a younger Valley Heads Moraine of

Ontario provenance. He identified till of eastern provenance beneath Valley Heads deposits at least as far west as Clinton.

Studies in adjacent regions support the concept of readvance events in the western Mohawk Valley. Stratigraphic work in the Hudson Valley during the late 1960's and early 1970's has shown that the Hudson-Champlain Lobe experienced cycles of advance and retreat (Connally and Sirkin, 1973). Well logs in the Schoharie Valley (LaFleur, 1969) and stratigraphic sections in the Mohawk Valley (LaFleur, 1979) record at least two advances of the Mohawk Sublobe. The general character of Late Wisconsinan deglaciation in the Mohawk Valley is compatible with the record of Late Wisconsinan ice-front oscillations in the Great Lakes region (Dreimanis and Goldthwait, 1973; Frye and Willman, 1973; Wright and others, 1973; Johnson, 1976; Evenson and others, 1977b)

APPROACH TO THE PROBLEM

Detailed mapping and stratigraphic investigations in the Mohawk Valley throughout the past decade, coupled with recent developments in sediment-facies analysis have greatly influenced recent interpretations of the glacial history of the region. These interpretations have been summarized by Muller and others (in review).

Late Wisconsinan Age of Deposits

Earlier work in the West Canada Valley shows tills of possible Middle or Early Wisconsinan age (Fullerton, 1971). This concept stems from an idea that prevailed in the that Late 1960's that Late Wisconsinan glaciation reached its maximum extent north of where the border is now placed (inset on Figure 1). Recent studies in Pennsylvania and New Jersey show that Late Wisconsinan (Woodfordian) ice extended well into eastern Pennsylvania and New Jersey (Crowl, 1980; Crowl and Sevon, 1980; Cotter and others, in press). If this border is indeed Late Wisconsinan, it is unlikely that portions of the Mohawk Valley, Tug Hill or southwestern Adirondacks would have remained ice-free through the whole Late Wisconsinan. All the tills previously thought to be Early or Middle Wisconsinan deposits in the West Canada Creek Valley are now known to occur as the upper-most till deposits at some localities. Also, they are all associated with ice-marginal deposits which have not been subsequently overridden. Uncovering of the surfaces of these tills must post-date the Late Wisconsinan covering of the region. Therefore, all deposits thus far encountered in the West Canada Valley and shown on this field trip are considered Late Wisconsinan (Figures 2 and 3). In the absence of any absolute dates these stratigraphic relationships provide an explanation of this age designation.

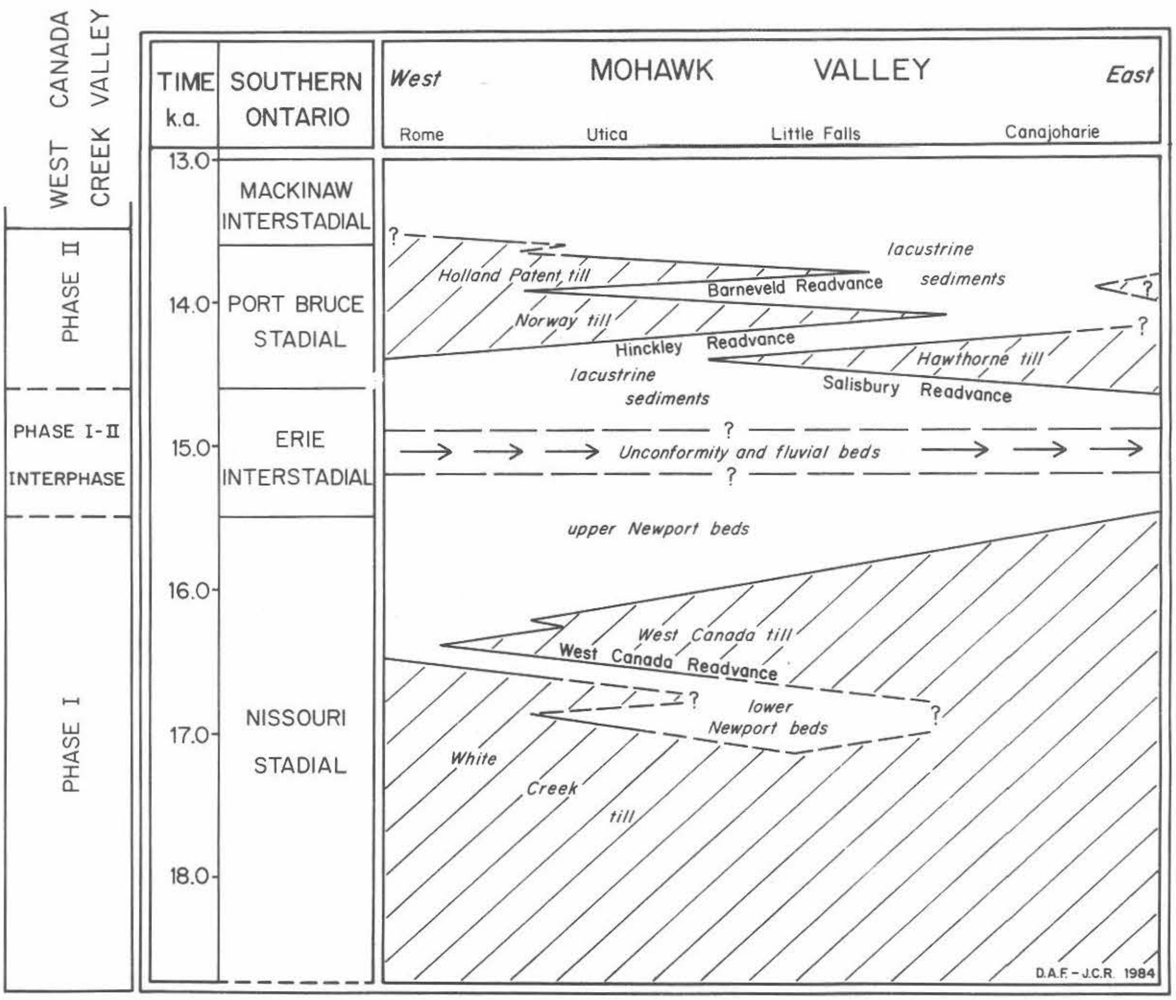


Figure 2. -- An east-west time-distance plot of readvances in the western Mohawk Valley (Muller and others, in review) with correlations to geologic-climate units of southern Ontario (Dreimanis and Karrow, 1972; Dreimanis and Goldthwait, 1973) as inferred by Muller and others (in review). Glacial lakes, tills and other deposits associated with readvances and retreatal phases are shown in italics. Column at left shows the deglaciation-phase terminology used in this report.

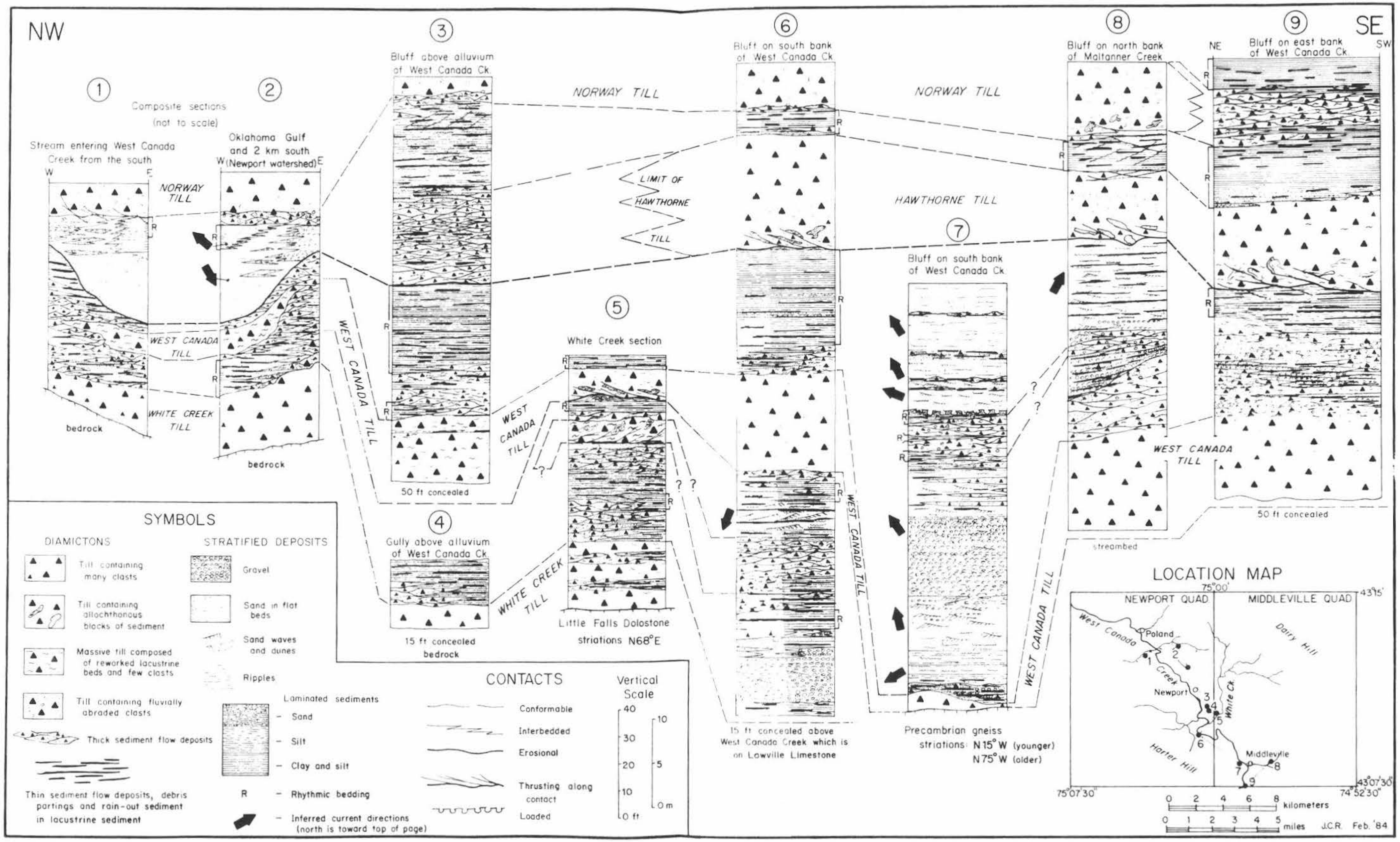


Figure 3. -- Representative stratigraphic sections from the West Canada Creek Valley (Newport and Middleville quadrangles) showing inferred correlations from northwest to southeast. Sections 1 and 2 are composite sections and are not drawn to scale. (STOP 1 is at Section 9; STOP 2 is at Section 5)

Provenance Investigations

A critical part of the formulation of the glacial history of the region is the development of provenance criteria for the different ice flow directions. Provenance data have been lacking in the West Canada Valley. Distinguishing the different source terranes in the field is very difficult and requires supporting laboratory analysis. Although compositional differences between till units have been observed within individual exposures, the observed variations are usually not consistent between widely-spaced localities. Lateral changes in underlying units may cause rapid changes in till composition. All provenance inferences must be made with supporting information at hand, i.e. bedrock maps, lithology of underlying glacial units and striation or till fabric (Foresti, 1984) data. Types of compositional data which have been used to distinguish till units are pebble and granule counts (Lykens, 1984), total carbonate analysis, dolomite and calcite percentages, major-element whole-rock geochemistry, and trace and minor-element analyses including Fe, Ti, Rb, Sr, Zr, Ba and Mn (Franzi, 1984). Heavy mineral data were used by Antonetti (1982) and Loewy (1984) but these data proved to be ambiguous for distinguishing between prospective metamorphic source terranes. The provenance of tills and lacustrine deposits is presently being investigated in the lower West Canada Valley using pebble counts, carbonate analysis and clay mineral X-ray analysis (Ridge, in prep.).

In the lower West Canada Valley, lacustrine sediments of Oneida Sublobe provenance can be recognized in the field as those that contain rain-out sediment which is red. In general, lacustrine sediments of Ontario provenance are lighter in color than Mohawk Sublobe sediments. Lacustrine sediments derived entirely from the Mohawk Sublobe do not contain red rain-out sediment and are darker in color. Rhythmites between the Hawthorne till and lacustrine sediment flows associated with the Norway till (STOP 1; Section 9 on Figure 3) show these differences. The lower half of the rhythmites contains upward-thinning varve couplets and drab, dark gray colors. Midway through the rhythmites, the couplets begin to thicken upward, show lighter colors, and contain red drop sediment. This succession shows a transition in the varves from an eastern (Mohawk Sublobe) provenance at the base to a western (Oneida Sublobe) provenance at the top.

In the western Mohawk Valley, Ontario Lobe tills may have a red color because of Vernon Shale and red lacustrine sediments that underlie these tills to the west. Tills from the east or of Mohawk provenance are never red-colored and have a more drab appearance. Unfortunately, these simple criteria cannot be used in the West Canada Valley where both Mohawk and Oneida Sublobe tills are gray.

Sediment - Facies Analysis

The sedimentologic distinction between till and sediment flows in diamict sequences is important to the reconstruction of the glacial history of the West Canada Valley. Particularly where deep lacustrine waters (as deep as 225 m) bordered the Late Wisconsinan ice sheet, thick sediment flows may have been deposited directly from the glacier and from valley sides. Delineation of the physical limits of till sheets requires the ability to differentiate tills from sediment flows. The works of Boulton (1968), Evenson and others (1977a), Lawson (1979), May (1977), and Hicock and others (1981) serve as guides to the recognition of sediment flows and tills.

Gravel deposits in the Mohawk Valley near Little Falls and in the West Canada Valley, previously identified as outwash (subaerial) deposits (Fullerton, 1971), are now recognized as subaqueous outwash (Rust and Romanelli, 1975) or subaqueous fan deposits (Boothroyd, 1984). The distinction between subaerial and subaqueous gravels is critical to discerning periods of lacustrine drainage and interstadial episodes.

Paleomagnetic Investigations

Analysis of paleomagnetic declinations preserved in fine-grained lacustrine sediments have provided an important time-based stratigraphic tool for testing correlations between nearby stratigraphic sections. Secular declination changes measured in the depositional remanent magnetism (DRM) are used for testing time equivalence between units. This technique is particularly applicable to the West Canada Creek Valley where exposures of suitable lacustrine sediments span most time intervals, exposures are abundant, and reproducibility can be demonstrated for the lacustrine units. Metamorphic rocks in the Adirondacks supply an abundance of fine-grained magnetic minerals (predominantly magnetite) to the glacial deposits of the area. For this reason remanent signals have high magnitudes and are very stable. Remanent signals from Mohawk and Adirondack provenance deposits have on the average 10 to 100 times higher magnitudes than Oneida Sublobe deposits. These differences probably result from disimilar magnetic mineral concentrations and provide another criterion for provenance studies. A summary of preliminary paleomagnetic results is shown on Figure 4.

Paleomagnetic secular variation curves may be used to test regional correlations within distances of about 500 kilometers from the study area. The western Mohawk Valley data are being compared to declination data from the Genesee River Valley of western New York (Brennan and others, 1982; Brennan and others, in prep.; Braun and others, 1984). Presently, the declination records from both

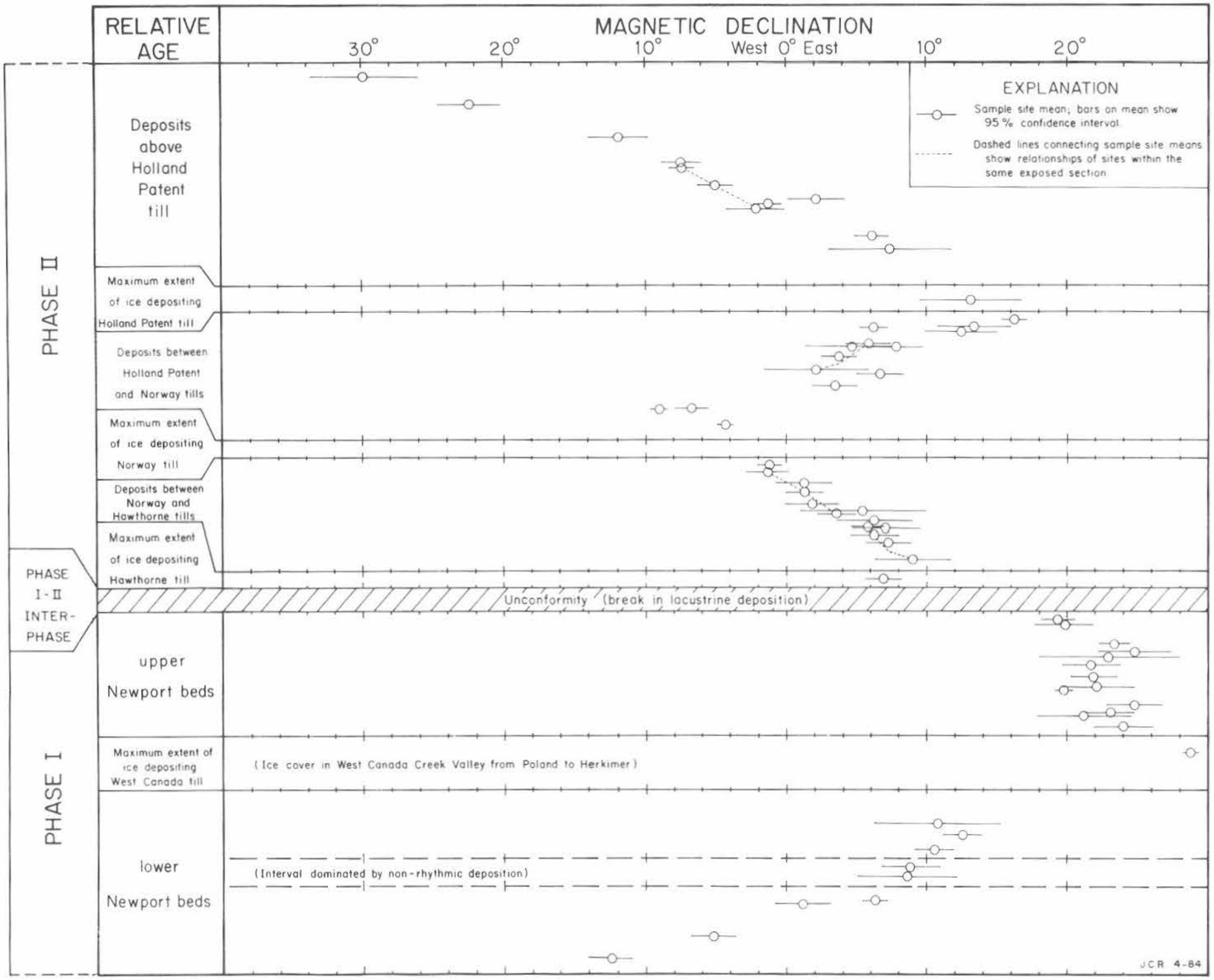


Figure 4.-- Paleomagnetic declination plotted against relative time as determined from relative ages of units from which sample cores were taken. Each point on the plot represents the mean value of 7 to 16 cores taken at one sample site or horizon.

areas are too incomplete to allow a decisive check on correlations. For periods during which the records may overlap, as indicated by correlations within the Valley Heads Moraines, the declination records are in agreement.

GLACIAL STRATIGRAPHY

The glacial stratigraphy of the West Canada Valley can be subdivided into two units of glacigenic deposits separated by an erosional unconformity and fluvial beds. The two units represent separate phases of Late Wisconsinan ice-front oscillation during general deglaciation. Deposits within the units are conformable except for local erosional disconformities which resulted from overriding glaciers. For discussion purposes only, these units will be referred to as deposits of: Phase I, the lower set of deposits, and Phase II, the upper set of deposits. The interval between them will be referred to as the Phase I - Phase II Interphase (Figure 2). The use of the terms phase and interphase are informal and without proven relationship to the geologic-climate classification of Dreimanis and Karrow (1972).

Phase I

White Creek Till

The lowest unit of Phase I deposition is the White Creek till which typically is stony, sandy and compact and contains a high proportion of metamorphic clasts. In exposures the lower contact of the till either lies directly on bedrock or is concealed. The till contains no reworked lacustrine sediment except in exposures along White Creek (STOP 2) where the upper part of the till is interbedded with sediment flows and laminated lacustrine deposits. Ice-flow indicators (till fabrics and striations) associated with the White Creek till indicate variable ice flow ranging from south to east. Southerly flow directions probably represent overriding of the area by thick ice, a conclusion that is supported by high proportions of Adirondack lithologies in the till. Southeasterly flow directions probably developed as a result of topographically controlled ice flow which is reflected by a greater proportion of local bedrock clasts in the till. Along White Creek (near STOP 2), striations (N70E) indicate flow from the west (Oneida Sublobe). These deposits may reflect a local oscillation of valley controlled ice flow at the margin of the receding Oneida Sublobe.

Lower Newport Beds

Lacustrine units of the lower Newport beds overlie the White Creek till. The unit generally becomes finer-grained upward and consists of cobbly to silty sediment flows, laminated silts and sands, and silty rhythmites. Along the headwater tributaries of White Creek the rhythmic couplets thin upward above the White Creek till but thicken and become more clayey near the base of the West Canada till. The occurrence of diamict layers of possible glacial and sediment-flow origin, suggests a glacier-proximal environment and possible readvance during deposition of the lower Newport beds (Sections 5 and 6 on Figure 3). In the upper White Creek Valley this part of the lower Newport beds is represented by thick turbidity and debris flow deposits that separate a lower silty rhythmite facies from an upper clayey facies. No provenance data or ice-flow indicators are available but current directions inferred from megaripples in sandy beds associated with the unit suggest a western source or Oneida Sublobe affinity (Section 6 on Figure 3).

West Canada Till

The West Canada till is an eastern (Mohawk Sublobe) provenance till which lies between the upper and lower units of the Newport beds. Facies of the till are highly variable in the West Canada Creek Valley from Middleville to Poland. Near Middleville (STOP 1; Sections 7, 8 and 9 on Figure 3) it is dark gray to black, stony and has a silty matrix. To the northwest in the West Canada Creek Valley the unit is characterized by a sparsely stony, silty to clayey till facies (STOP 2; Sections 1 thru 6 on Figure 3). The silty and clayey facies is displayed along the tributaries of White Creek and in the Shedd Brook area where the till overlies clayey sediments of the lower Newport beds. The increase in clay content and decrease in stoniness is in the inferred direction of ice flow. At higher elevations along the southwestern flank of Dairy Hill, the West Canada till exhibits a stony character and is sandier than in the West Canada Valley. This facies may reflect thinner and sandier sequences of lacustrine sediments beneath the till in upland areas or greater contributions of metamorphic Adirondack lithologies along the northern margin of the till sheet in upland areas.

Upper Newport Beds

The upper Newport Beds are dominated by upward-thinning, clayey and silty rhythmites which contain rippled sand beds and turbidites (Sections 3 and 6 on Figure 3). Thick sequences (as thick as 40 m) of subaqueous outwash sands and gravels and sediment flows may be found associated with depo-centers at the receding Mohawk Sublobe ice front. Subaqueous fan deposits are well exposed along West Canada Creek at Middleville (Section 7 on Figure 3). Current directions in these deposits indicate a source to the southeast. At many other sections in the West Canada Creek and White Creek valleys paleocurrent flow to the northwest has been inferred from rib and furrow structures and flutes on the parting planes of finer-grained laminated silts and clays.

Meltwater Deposits in the Upper West Canada Creek Valley

Recession of the Black River Sublobe during the waning stages of Phase I is recorded by proglacial sediments in two exposures in the Cincinnati Creek Valley, approximately 1.5 km east-northeast of Barneveld (STOP 4; Figure 5). The Phase I sediments at both exposures are truncated by the Norway till (Phase II) which, in turn, is overlain by younger lacustrine and deltaic sediments. The variability in the stratification and the texture of the Phase I lithofacies, the presence of lacustrine sand and rhythmites within the stratigraphic sequences, and the strong, unidirectional paleocurrents are consistent with the interpretation of these deposits as subaqueous outwash (Rust and Romanelli, 1975) or subaqueous fan deposits (Boothroyd, 1984). Paleocurrents, clast provenance, and upward fining of texture suggest that the units may have been deposited as esker fans from a northward-retreating (Black River Sublobe) ice front (Figure 6).

The configuration of the proglacial lake into which the Phase I sediments at Cincinnati Creek were deposited must be inferred from isolated deposits which survived subsequent glacial events. Ice-marginal delta deposits at Bailey and Ninety Five hills (STOP 6), approximately 10 km northeast of Barneveld, record an episode of deltaic sedimentation, from Black River Sublobe source, into glacially ponded water at an elevation in excess of 475 m. These deposits are almost 33 m higher than the deltas deposited into glacial Lake Miller (Phase II), and thus, record an earlier, higher level lake phase. Accordant elevations on Sand Hill, a kame (delta?) complex 1 km northeast of Cold Brook, suggest that deposition was controlled by the same lake level. These ice-contact drift facies are probably closely synchronous with the deposition of a thick sequence of lacustrine rhythmites which unconformably underlie Phase II deltaic sediments in bluff sections along the southern shore of the Hinckley Reservoir. These data indicate the existence of an extensive high-level lake in the upper West Canada Creek Valley during the initial stages of deglaciation. Such high levels of impoundment require extensive ice dams in the Oneida and Mohawk lowlands in order to prevent southward drainage through lower cols of the Appalachian Upland. The impoundment, therefore, may be associated with the readvance of the Mohawk Sublobe which deposited West Canada till in the lower West Canada Creek and Mohawk Valleys.

THE CINCINNATI CREEK SECTIONS

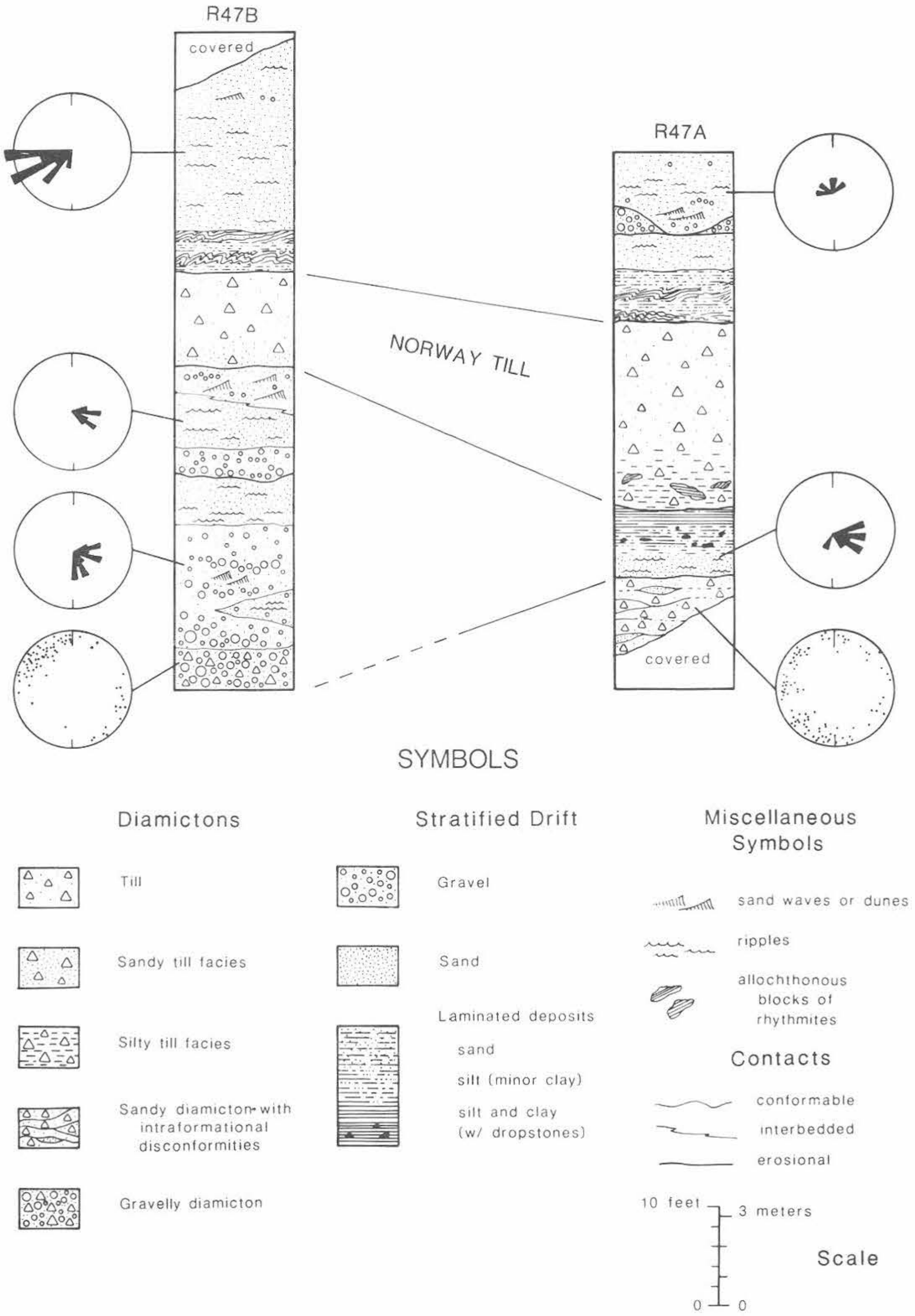


Figure 5. -- Representative stratigraphic sections of the exposures along Cincinnati Creek, showing inferred correlations. Dip-line plots of elongate clasts and rose diagrams are drawn with north toward the top of the page. The outer circles of the rose diagrams represent five current measurements.

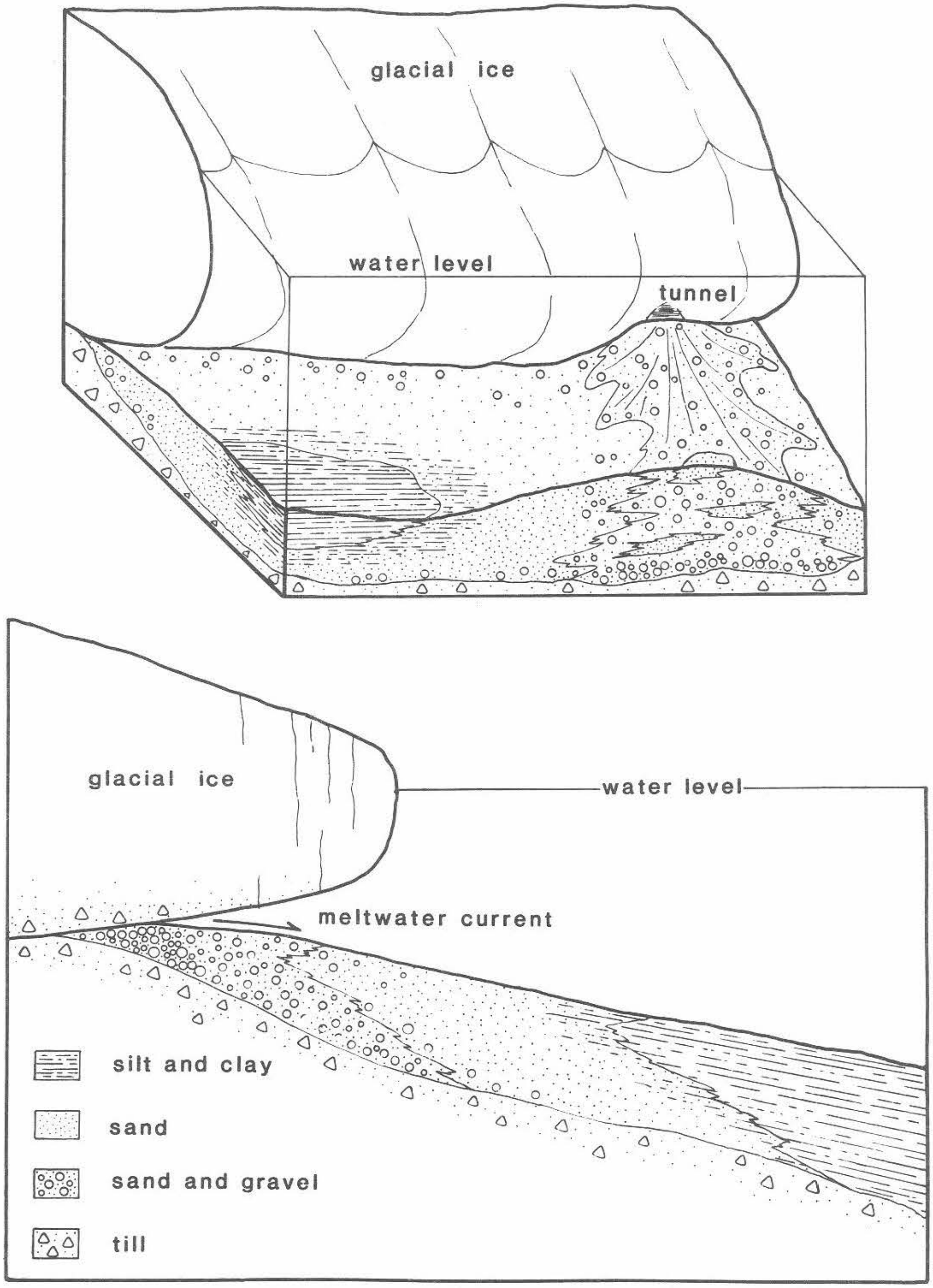


Figure 6. -- Inferred esker-fan sedimentation interpreted from sediment facies observed in sections along Cincinnati Creek (STOP 4; Figure 5) in Phase I sediments.

Phase I - Phase II Interphase

Deposits which underlie the Hawthorne till show evidence of an erosional unconformity and fluvial deposition. Evidence for the erosional period, here referred to as the Phase I-Phase II Interphase, is outlined below and in Figure 7.

1. The nature of the lower contact of the Hawthorne till suggests that the underlying sediments were subglacially eroded and deformed by the glacier that deposited the till (STOP 1; Sections 6 and 9 on Figure 3). At many exposures the till truncates rhythmites of the upper Newport beds, which contain upward-thinning varve couplets, and no intervening proglacial sediments are present. The apparent lack of proglacial sediment may indicate extensive subglacial erosion as the Mohawk Sublobe advanced into the West Canada Creek Valley. Alternatively, proglacial sedimentation may have been focused into the deeper portions of the lake basin by density underflows emanating from the ice-front. The apparent lack of proglacial sediment may reflect non-deposition in the higher elevations of the lake basin as well as subglacial erosion.

2. Outside the limits of the Hawthorne till, proglacial lacustrine sediments, which underlie the Norway till and are, in part, time-equivalent to the Hawthorne till, show an unconformable contact with the upper Newport beds (Sections 1 and 2 on Figure 3). Within the limits of the Hawthorne till sheet, they have a conformable contact with the top of the Hawthorne till (Sections 6, 8 and 9 on Figure 3). Immediately beyond the limits of the Hawthorne till, sediment flows which appear to be proglacial sediments related to the Hawthorne till have an unconformable relationship with the Newport beds (Section 3 on Figure 3).

3. In the Mohawk Valley, 6 km south-southeast of Little Falls, the Hawthorne till and associated sediment flows overlie fluvial gravels (Lykens, 1984). The gravels display crossbedding and imbrication which indicate a paleocurrent flow to the east during a period of subaerial sedimentation. The upper contact of these gravels marks a transition upward from fluvial to lacustrine conditions during a readvance of the Mohawk Sublobe.

Differences in the thickness and physical character of glacial sediments in the West Canada Creek and Mohawk River valleys are probably related to differences in elevation of exposures in the two areas. In the West Canada Valley, the upper surface of the Newport beds is only exposed at elevations of 213 to 381 m while fluvial gravels in the Mohawk Valley are exposed at elevations no higher

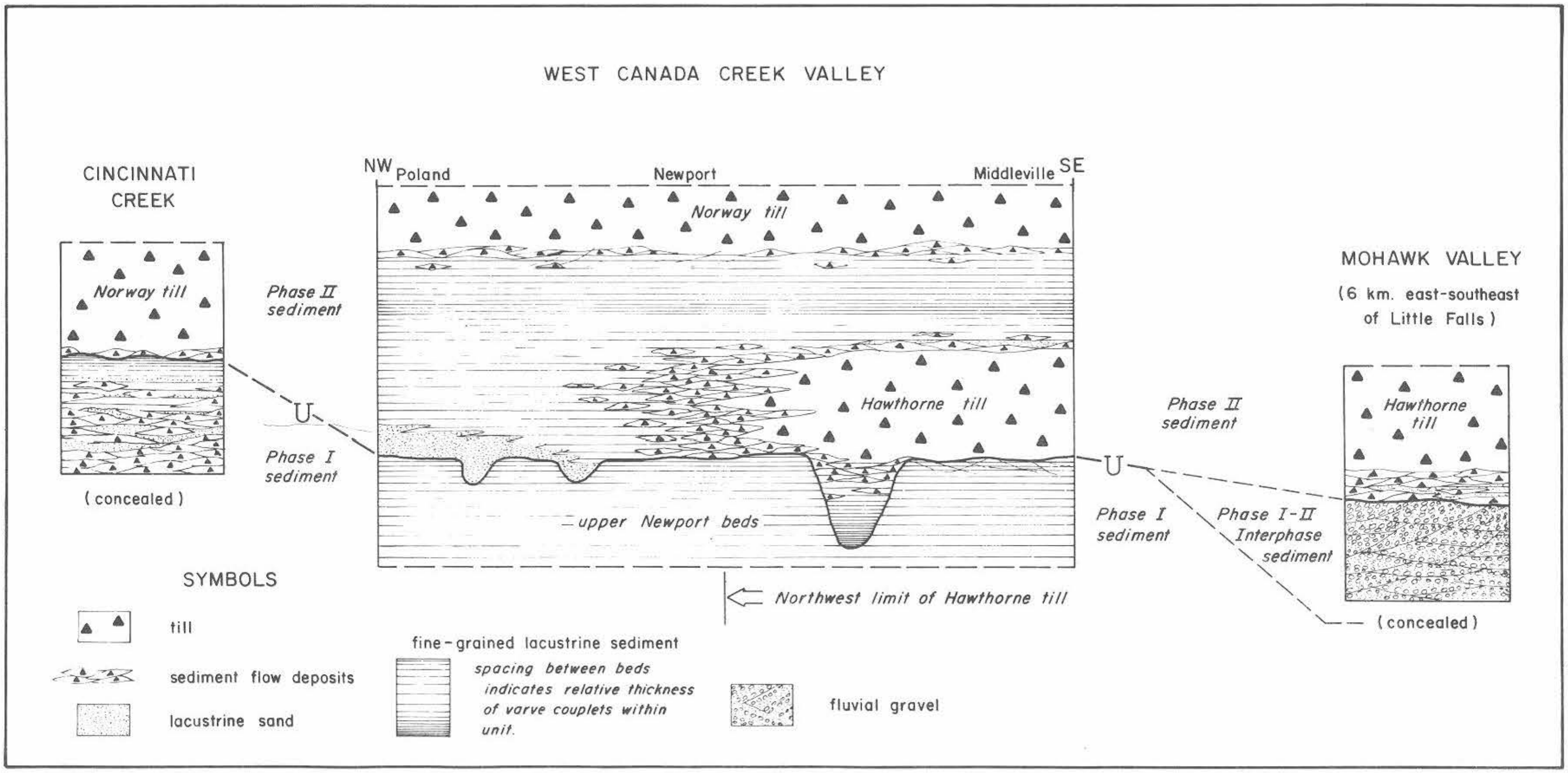


Figure 7. -- Generalized cross sections and stratigraphic relationships of the unconformity and fluvial beds of the Phase I-II Interphase showing the underlying and overlying units in the Cincinnati Creek, West Canada Creek and Mohawk River valleys.

than 122 meters. Subaerial exposure during the Phase I-Phase II Interphase resulted in erosion and dissection of deposits in the West Canada Creek Valley while fluvial gravels were deposited in the Mohawk River Valley.

Phase II

Hawthorne Till

The Hawthorne till is a black to dark gray silty, moderately stony till dominated by black shale clasts and containing rare sandstone clasts (Sections 6, 8 and 9 on Figure 3). To the northwest, the limit of the Hawthorne till is marked by a transition from till to sediment flows (Section 3 on Figure 3). Further up-valley the sediment flows probably correlate with a rhythmite sequence that has a distinctly dark, drab color and northwesterly paleocurrents (STOP 3; Sections 1 and 2 on Figure 3). Laminated and rippled sands below the rhythmites probably represent lacustrine deposition by drainage into the upper West Canada Valley from the north prior to the full impoundment of the valley by the Mohawk Sublobe. A reconstruction of ice deployment and proglacial lakes at the maximum extent of the Mohawk Sublobe during Phase II is shown on Figure 8.

Norway - Hawthorne Interval

Rhythmites deposited between the Hawthorne and Norway tills and widespread at elevations of 210 to 260 meters (STOP 1; Sections 6, 8 and 9 on Figure 3) have been described previously in relation to provenance criteria of the Oneida Sublobe (p. 7). The rhythmites record, through variations in composition and varve couplet thickness, a transition from an eastern source (Mohawk Sublobe) to a western source (Oneida Sublobe). At section 9 (Figure 3) rhythmites between the Hawthorne till and sediment flows related to the Norway till record continuous deposition for about 160 years.

Norway Till

In the West Canada Creek Valley, the Norway till is a clayey to silty, sparsely to moderately stony gray till which contains lithologies from an Oneida Sublobe source. The limit of the Norway till closely coincides with ice-marginal deltas deposited in Lake Miller, an impoundment in the upper West Canada Creek Valley at the former confluence of the Oneida and Black River Sublobes (Figure 9). Lacustrine sands and numerous ice-marginal deltas of the Hinckley Moraine System mark the maximum extent and recession of the Oneida and Black River Sublobes near their suture. To the southeast, the limit of the Norway till is traceable across the East Canada Creek

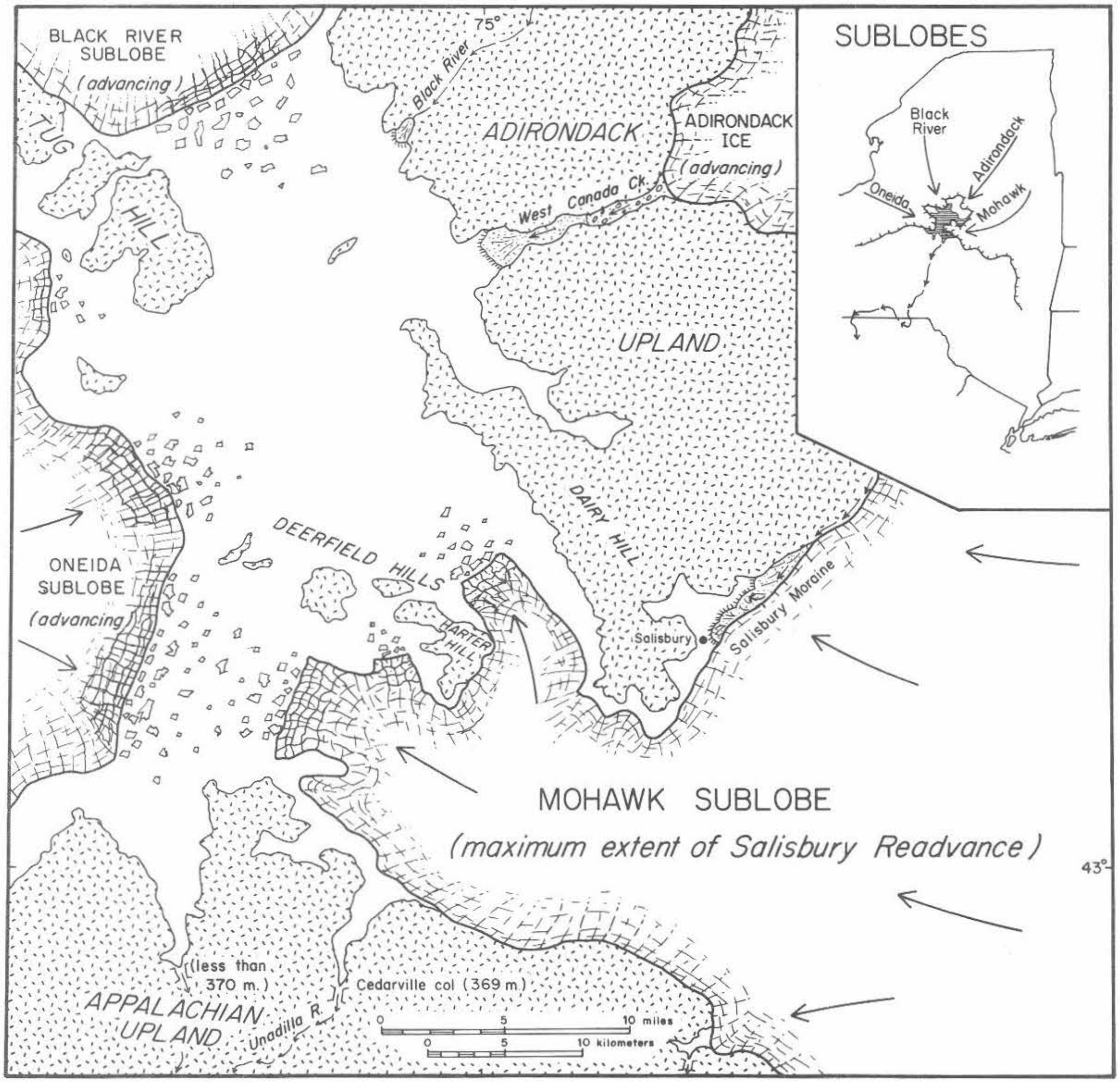


Figure 8. -- The inferred deployment of ice at the time of the maximum extent of the Salisbury Readvance of the Mohawk Sublobe. The Black River, Oneida and Mohawk Sublobes are drawn with calving margins where they terminated in deep water. Cedarville col may have been the outlet for ponded water in the region but the col to the west, although now higher than Cedarville col, may also have served as an outlet. (Base map is Figure 1)

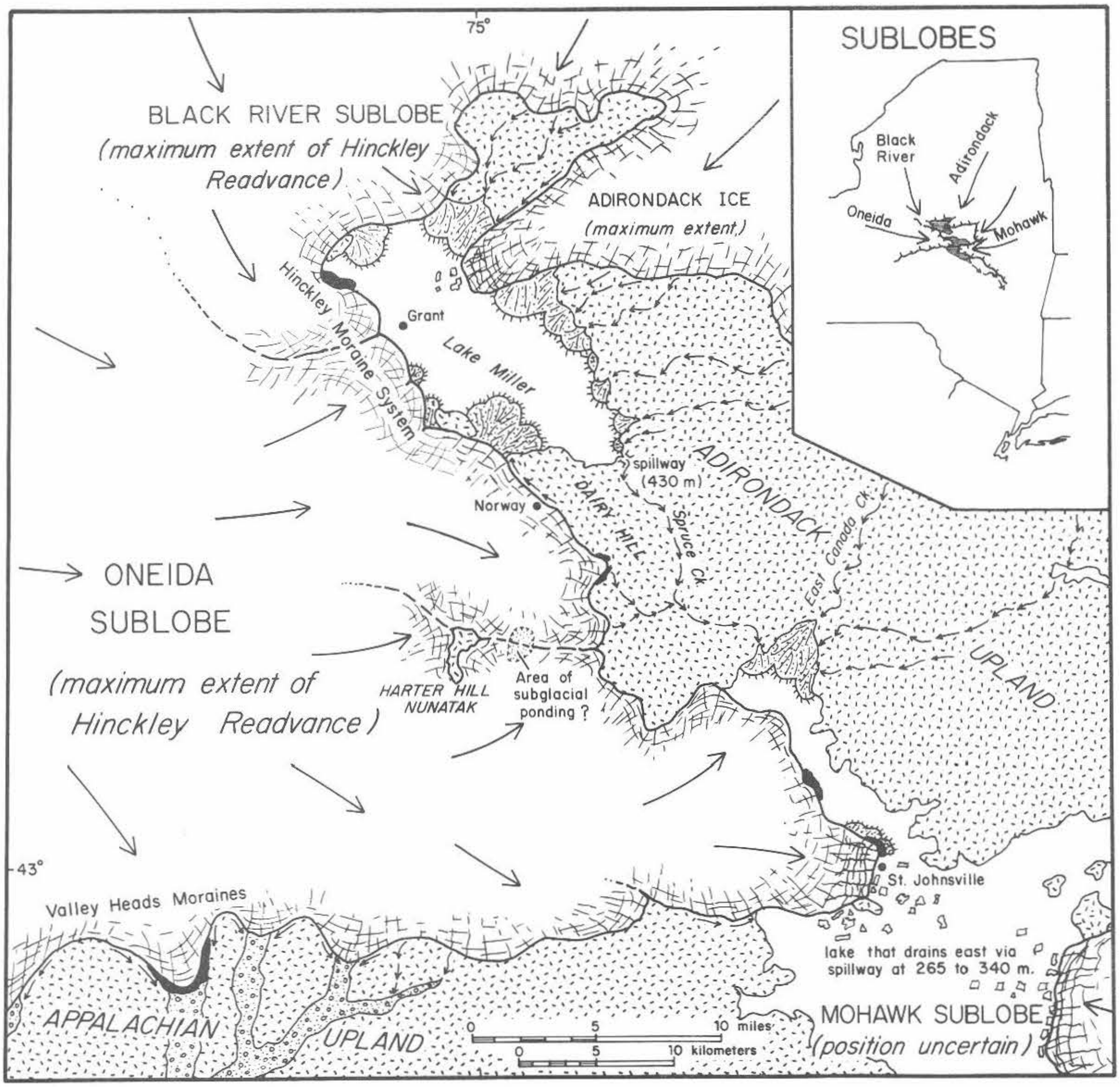


Figure 9. -- The inferred deployment of ice at the time of the maximum extent of the Hinckley Readvance of the Black River and Oneida Sublobes which ponded glacial Lake Miller in the upper West Canada Creek Valley. The exact position of the Mohawk Sublobe is unknown, but it remained far enough west to pond water above an elevation of 265 meters in the Mohawk Valley. Adirondack ice may have reached the maximum position of a readvance into Lake Miller. Till stratigraphy confirming this hypothesis is lacking and this interpretation is based on morphostratigraphic evidence from deltaic deposits at the readvance limit. (Base map is Figure 1; Blackened area at glacier terminus represents either an end moraine or large kame deposit)

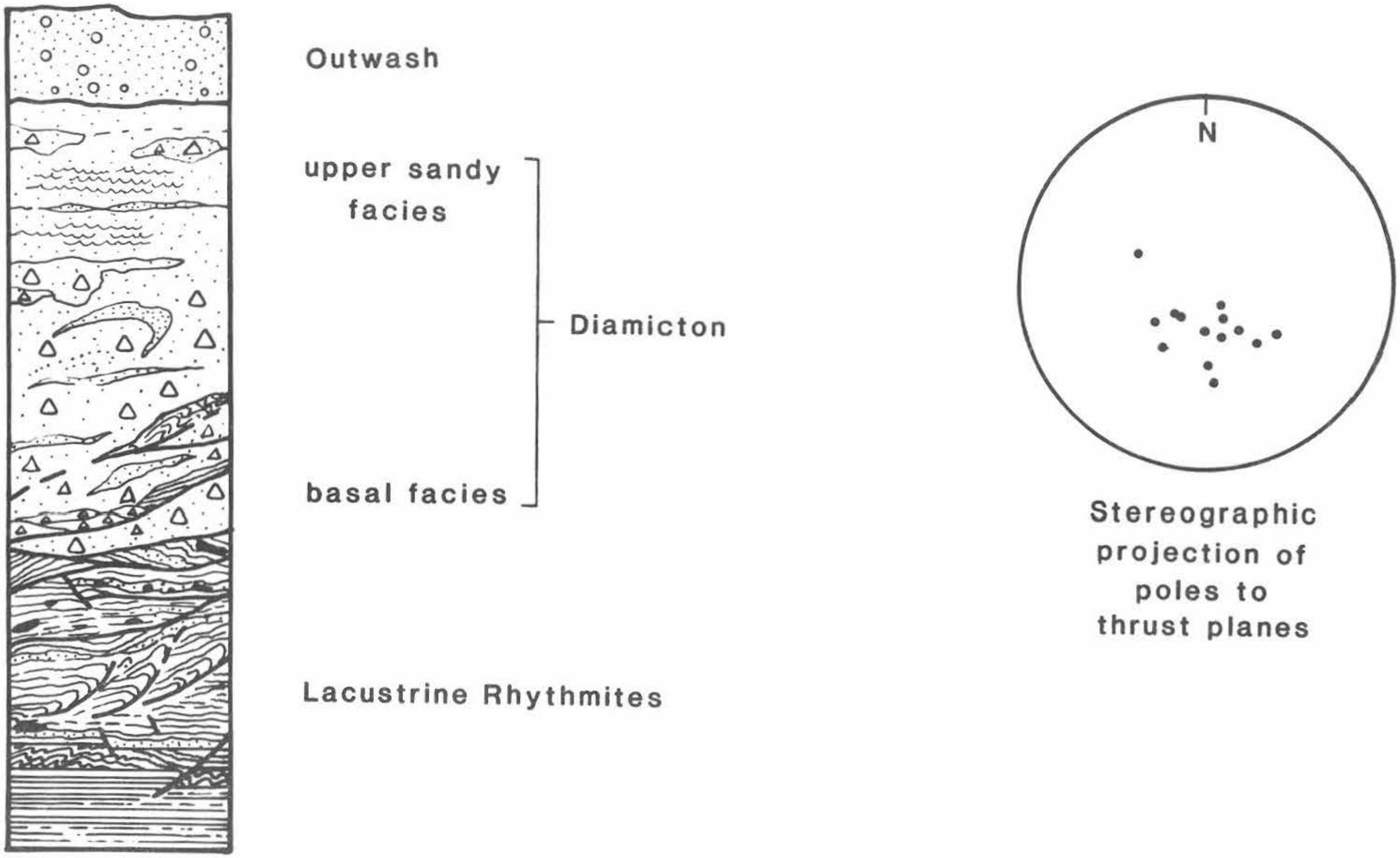
Valley to the Mohawk Valley near St. Johnsville (Lykens, 1984).

The sequence of sediment flows at Section 9 (Figure 3; STOP 1) correlate with the Norway till at Section 8 (Figure 3). The close association of the sediment flows and the Norway till suggest that they may have been deposited in an isolated body of water, possibly subglacially ponded, near the confluence of ice tongues of the Oneida Sublobe which flowed around Harter Hill (Figure 9). This configuration of ice masses is consistent with the hypothesis that Harter Hill stood as a nunatak at the Hinckley Readvance maximum. Northeast of Middleville, the Norway till limit occurs between elevations of 400 and 425 meters. On the flank of Harter Hill, an ice margin at this elevation would leave part of the hill uncovered. Coalescing ice in the West Canada Valley may not have developed enough thickness or persisted long enough to fully expel lacustrine waters trapped beneath it in the vicinity of Section 9 (Figure 3; STOP 1).

Alder Till

The Alder till is a Black River Sublobe equivalent of the Norway till and is highly variable in composition and texture. In the southwestern Black River Lowland the till is dark gray, moderately calcareous, and has a silty clay to clay loam matrix. Clasts of dark gray siltstone and shale and gray limestone reflect an eastern Tug Hill provenance. The absence of rounded red and green Medina Sandstone cobbles serves to distinguish the silty facies of the Alder till from the Norway till (Oneida Sublobe) with which it is closely associated. In the eastern Black River Lowland the unit is a light gray to gray-brown, slightly calcareous to noncalcareous till in which subangular to rounded clasts of various metamorphic rock types dominate. Because of its loose and permeable texture, the sandy facies of the Alder till is poorly exposed. Transitional facies of these two lithotypes are uncommon which may reflect lack of mixing of source materials in the Black River Lowland or the burial of transitional facies beneath younger lacustrine sediments.

The maximum southeastern extent of the Black River Sublobe during the Hinckley Readvance (Figure 9) is evidenced by exposures of silty diamicton over lacustrine sediments in bluffs on the shore of Hinckley Reservoir, 3.2 km northeast of Hinckley (STOP 5; Figure 10). The intense intrastratal fluidization and southward-directed shearing observed in the lacustrine unit is interpreted as glaciotectonic in origin, and thus, the diamicton is considered to be a lacustrine facies of the Alder till. The upper sandy facies of the diamicton probably reflects the waning stages of the readvance with much of the deposition occurring beneath an alternately grounded and ungrounded glacier sole. These upper facies were probably subject to a variable amount of resedimentation within the



Stereographic projection of poles to thrust planes

Figure 10. -- Stratigraphic section exposed in bluffs on the south shore of Hinckley Reservoir, 3.2 km northeast of Hinckley (STOP 5). Section shows silty diamicton overlying lacustrine sediments. Stereographic projection is a plot of poles to thrust planes measured in the lacustrine sediments. Symbols used are the same as those in Figure 5.

lake basin.

Norway - Holland Patent Interval

Rhythmites were deposited on top of the Norway till and its associated sediment flows as the Oneida Sublobe receded (STOP 1; section 9 on Figure 3). Varves between the Norway and Holland Patent tills in exposures along North Creek, 0.7 km east of Eatonville, record at least 140 years of continuous lacustrine deposition (Flick, in prep.). Sediment flows occur within the varves at the top of the Norway till and varve couplets thin upward. The varve couplets thicken upward beneath the Holland Patent till and contain sediment flows just below the Holland Patent till. The composition of the varves and sediment flows indicates a western (Oneida Sublobe) provenance.

Holland Patent Till

The Holland Patent till is a clayey, sparsely to moderately stony, gray till containing lithologies of Oneida Sublobe provenance. It is difficult to distinguish the Holland Patent till from the Norway till except where the two are observed in superposition. Commonly, the Holland Patent till is more clayey and has fewer clasts than the Norway till. The limit of the Holland Patent till coincides with end moraines along the southern flank of the Deerfield Hills (Figure 11). In the West Canada Valley ice-marginal deltas were deposited at the limit of the Barneveld Readvance in a lake having an elevation of 290 to 305 meters. This lake may have been continuous with a high-level proglacial impoundment in the eastern Mohawk Valley which drained across a spillway at Delanson col.

"Indian Castle Drift"

Fullerton (1971) applied the term "Indian Castle Readvance" to an expansion of the Ontario Lobe during a period of free eastward drainage in the Mohawk Valley (Figure 12A). Deposits of "Indian Castle Drift" include the Norway and Holland Patent tills described in this report. Furthermore, detailed mapping has shown that the limit of the Indian Castle Readvance corresponds to two separate readvance limits, the Hinckley and Barneveld Readvance limits (Figure 12B). The Indian Castle Readvance corresponds to the Hinckley Readvance from the Hinckley Moraine System southeast to Fairfield. From Fairfield to Indian Castle the Indian Castle Readvance limit corresponds to the Barneveld Readvance limit. The name "Indian Castle" has been abandoned for these reasons (Muller and others, in review).

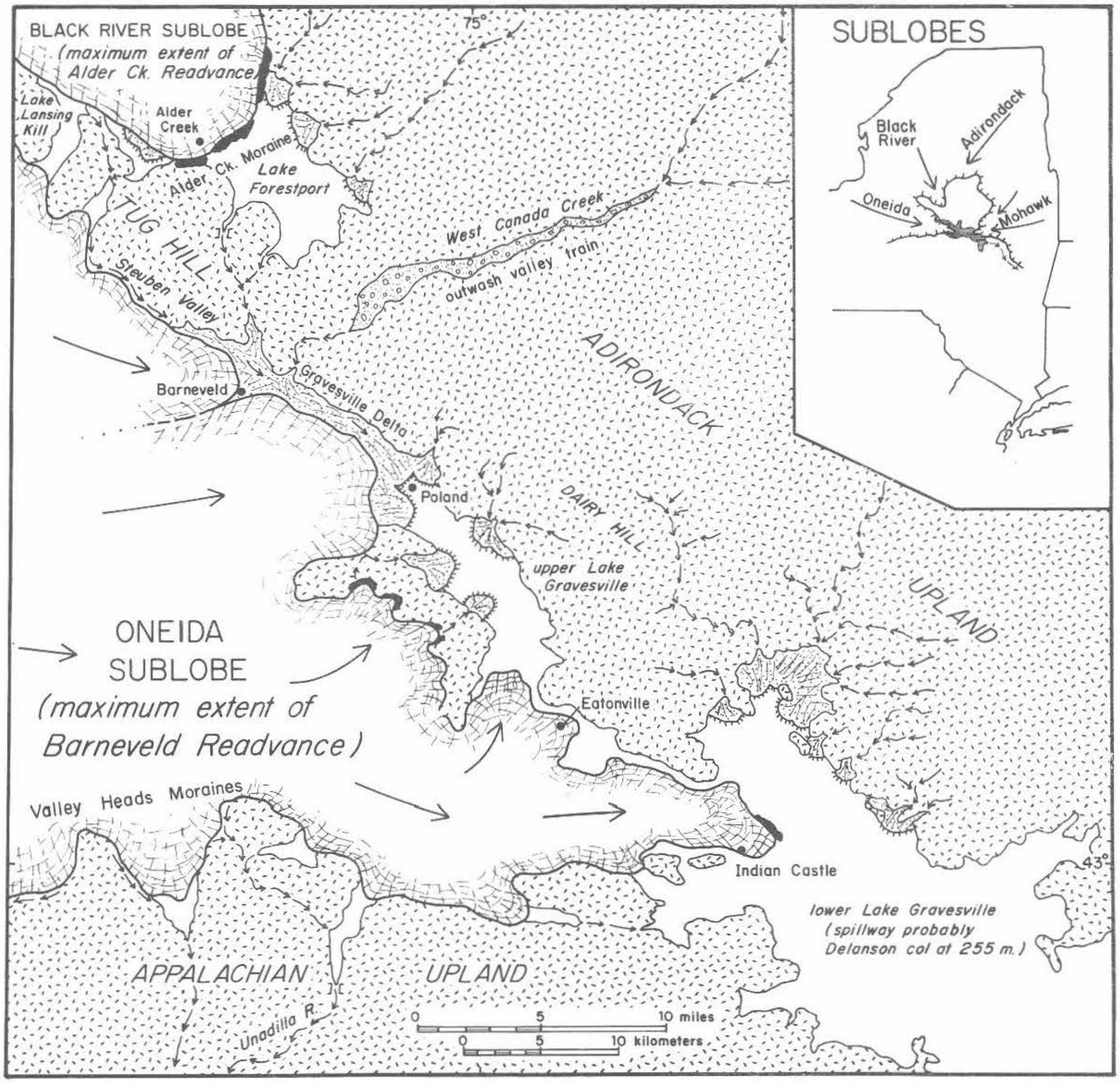


Figure 11. -- The inferred deployment of ice at the maximum extent of the Barneveld Readvance of the Oneida Sublobe. During the Barneveld Readvance upper Lake Gravesville probably remained connected to the main body of water, lower Lake Gravesville, which may have had a spillway at Delanson east of the area shown here. The Alder Creek Readvance of the Black River Sublobe, which ponded glacial Lake Forestport in the Black River Valley, was probably synchronous with the Barneveld Readvance. Adirondack ice was probably just beyond the northeast corner of the map. The exact position of the Mohawk Sublobe is unknown, although it remained far enough west to pond Lake Gravesville above 255 meters in the Mohawk Valley. (Base map is Figure 1) Blackened areas at the terminus of glacier represent either an end moraine or large kame deposit.

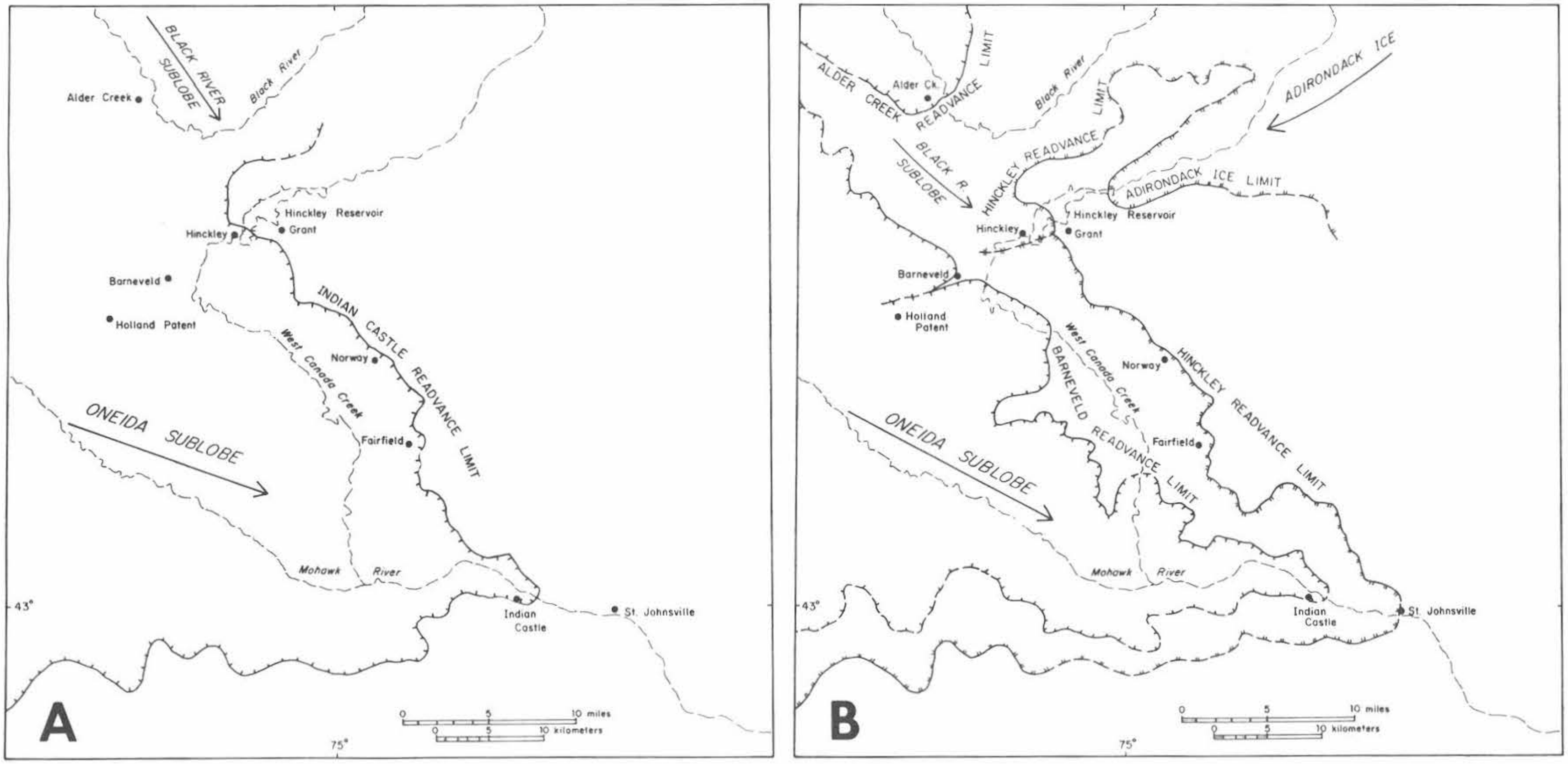


Figure 12. -- A. Maximum eastern extent of the "Indian Castle Readvance" of Fullerton (1971). B. Maximum positions of the Oneida and Black River Sublobes during the Hinckley and Barneveld Readvances and the inferred Alder Creek Readvance. The position of Adirondack ice during the Hinckley Readvance is inferred from ice-marginal deltas deposited in Lake Miller at the eastern end of the Hinckley Reservoir. (Base map for A and B is Figure 1)

Later Deposits

During later phases of deglaciation, readvances were restricted to the extreme western end of the Mohawk Valley and thus did not reach the West Canada Creek Valley. The valley did serve, however, as a major drainage outlet for proglacial impoundments in the upper Mohawk, Ninemile Creek and Black River valleys and from local Adirondack lakes and inwash drainage (Figure 13). At least three levels of valley train deposits, graded to falling lake levels in the Mohawk Valley and local knick points, were formed during ice recession. At Herkimer, West Canada Valley drainage built a delta with topset-foreset elevations of about 140 meters in a Mohawk Valley impoundment.

POINTS FOR DISCUSSION

Correlation to Eastern Great Lakes

Muller and others (in review) proposed correlations of the glacial events in the western Mohawk Valley to those in the Erie and Ontario basins (Dreimanis and Karrow, 1972; Dreimanis and Goldthwait, 1973). These correlations (Figure 2) were based on lithostratigraphic and morphostratigraphic information without supporting radiometric dates. The Erie-Ontario basin nomenclature appears to be the most appropriate in light of its close proximity to the West Canada Valley. This approach is favored over formulating new stratigraphic nomenclature because a record of Ontario Lobe activity is preserved in the West Canada Valley region and reasonable correlations may be formulated.

Two ties may exist between the stratigraphy of the West Canada Valley and the eastern Great Lakes. First, the unconformity and fluvial deposits of the Phase I-Phase II Interphase represent a major interstadial event. They record a period of erosion and fluvial deposition which requires recession of the Mohawk Sublobe to permit eastern fluvial drainage of the Mohawk Valley. The Phase I-Phase II Interphase is thought to represent the Erie Interstadial at which time the Great Lakes drained east across the divide at Rome to the Mohawk and Hudson Valleys (Mörner and Dreimanis, 1973). The unconformity and deposits representing this period further suggest an Erie Interstade equivalence by the distance of ice recession involved, and the fact that they are the only evidence of widespread erosion older than deposits equivalent to the Valley Heads Moraines.

The second tie to the Mohawk Valley stratigraphy is the group of outer moraines of the Valley Heads Moraine System (Muller, 1965) which appear to be correlative with the Norway and Holland Patent tills (formerly Indian Castle Drift of Fullerton, 1971; Muller and others, in review). Lateral tracing of the "Advanced Valley Heads

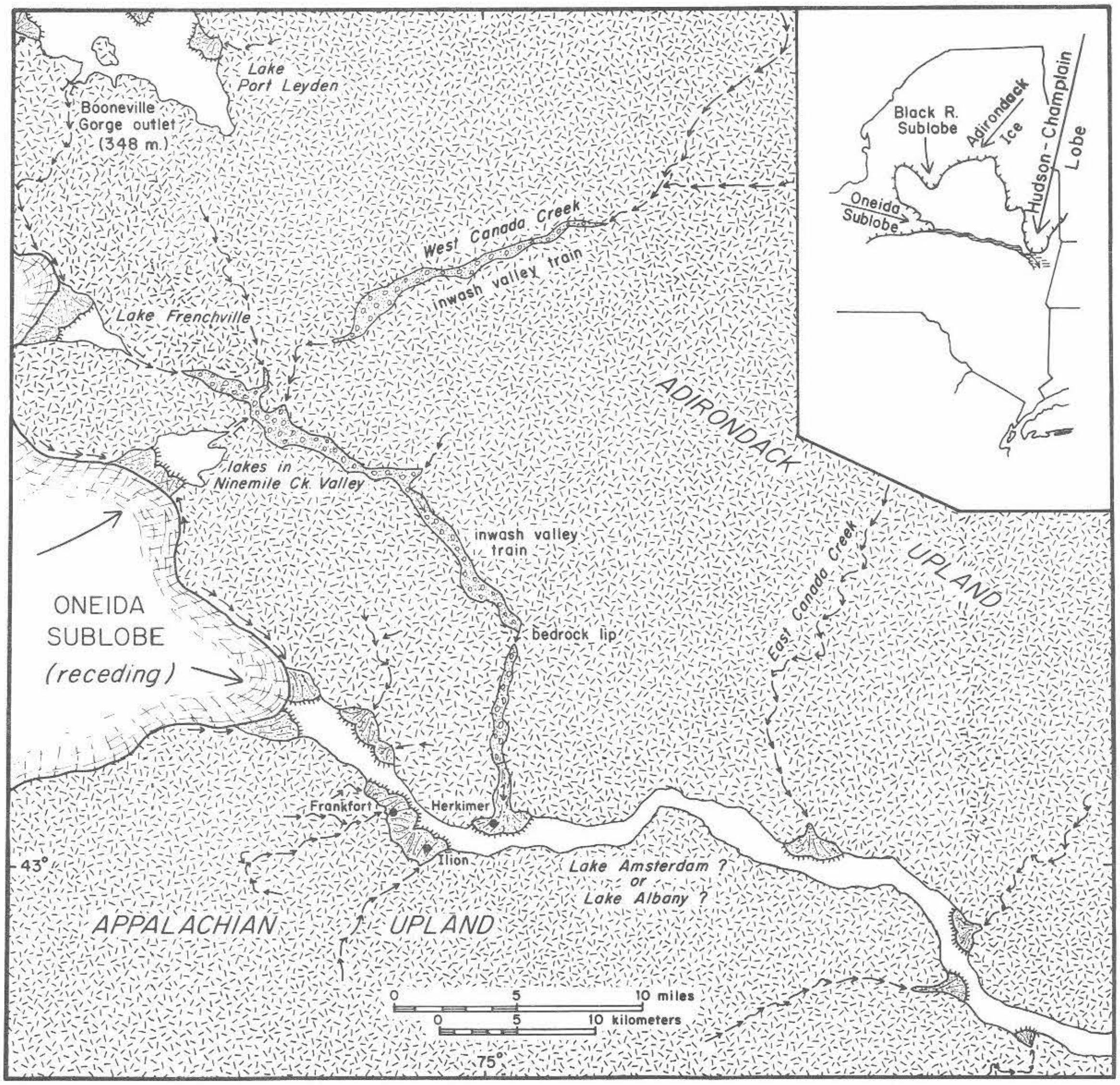


Figure 13. -- The inferred deployment of ice during the final recession of glacial sublobes from the West Canada Creek Valley. The Oneida Sublobe occupied the western end of the Mohawk Valley and ponded lakes in the upper Mohawk and Ninemile Creek valleys which drained into the West Canada Creek Valley. The Black River Sublobe ponded Lake Port Leyden in the Black River Valley which drained into the West Canada Valley via the Steuben Valley. The position of the Mohawk Sublobe is unknown but it may have ponded the Mohawk Valley to form Lake Amsterdam or receded from the eastern Mohawk Valley and allowed Lake Albany to inundate the valley. Adirondack ice receded from the upper West Canada Creek drainage basin but locally ponded glacial lakes in the Adirondacks may have drained into the West Canada Creek Valley. (Base map is Figure 1)

Moraine" of central New York (Muller, 1966) to western New York suggests that it is morphostratigraphically equivalent to the Valley Heads Moraine at Portageville in the Genesee Valley (Wyoming County) and the Lake Escarpment Moraines in the Erie Basin (Muller, 1977). The moraines pre-date the Gowanda Moraine, post-date the Kent Moraine and are probably Port Bruce in age. These correlations, would give a Port Bruce age to the Norway and Holland Patent tills. The Hawthorne till, deposited by ice of an eastern source (Mohawk Sublobe) is closely associated with the Norway till in age (about 200 years older) and for this reason would probably be a Port Bruce deposit.

Correlations to the East

The positions of till limits from the Mohawk Sublobe in the West Canada Valley suggest tentative correlations with ice margins, end moraines and possible readvance limits to the east. Tentative correlations for discussion are show in Table 1.

Parallel Response of the Ontario and Hudson-Champlain Lobes

The West Canada Valley stratigraphy allows the detailed study of readvance synchroneity between the Hudson-Champlain and Ontario Lobes during Phase II of deglaciation. The Black River and Oneida Sublobes of the Ontario Lobe appear to have responded to the same major climatic stimuli as the Mohawk Sublobe of the Hudson-Champlain Lobe. Interesting also is the failure of these sublobes to attain their maximum expansions simultaneously. Both the Hudson-Champlain and Ontario Lobes retreated during the Phase I - Phase II Interphase. Both lobes readvanced at the close of this interphase and reached their maximum extent in the West Canada Valley asynchronously. The Mohawk Sublobe reached its maximum extent at least 160 years prior to the full expansion of the Oneida Sublobe as determined by varve counts between the Hawthorne and Norway tills (Section 9 on Figure 3). Possible explanations may be different response times reflecting different distances from a source of outflow or differing contributions from Adirondack through flow or local Adirondack sources (Muller and others, in press).

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WEST CANADA VALLEY TILL SHEET MARGINS	WESTERN MOHAWK VALLEY	SCHOHARIE AND EASTERN MOHAWK VALLEYS
HAWTHORNE TILL LIMIT	SALISBURY MORAINE (0.8 km N of Salisbury, Salisbury Quad.) PINNACLE KAME MORAINE (Cushing, 1905)	MIDDLEBURG ICE MARGIN
WEST CANADA TILL LIMIT	DIAMOND HILL DELTA Ice marginal delta from Hedgehog Mtn. to Diamond Hill (3.5 km NW or Salisbury, Salisbury Quad.) CASSVILLE-COOPERSTOWN MORAINE (Krall, 1977)	WAGON WHEEL GAP MORAINE (Rich, 1935)

Table 1. -- Tentative correlations of till limits in the West Canada Valley and ice margins, end moraines and possible readvance limits in the Mohawk Valley region.

Scientific Research Society, the Senate Research Fund of Syracuse University, the Geology Department of SUNY at Geneseo, and the New York State Geological Survey.

REFERENCES

Antonetti, M.D., 1982, The Pleistocene geology of the South Trenton, New York 7.5-minute quadrangle: Unpub. M.S. thesis, Syracuse Univ., Syracuse, NY, 100 p.

Boulton, G.S., 1968, Flow tills and some related deposits on some Vestspitsbergen glaciers: Jour. of Glaciology, v. 7, p. 391-412.

Boothroyd, J.C., 1984, Glaciolacustrine and glaciomarine fans: a review: Geol. Soc. America Abstracts with Programs, v. 16, no. 1, p. 4.

Braun, D.D., Helfrick, E.W., Jr., Olenick, G.F. and Brennan, W.J., 1984, Using secular variation of geomagnetic declination to test the age of the Kent Moraine in the Genesee Valley, New York: a progress report: Geol. Soc. America Abstracts with Programs, v. 16, no. 1, p. 5.

Brennan, W.J., 1981, Port Huron advance in western New York, geomagnetic and stratigraphic evidence: Geol. Soc. America Abstracts with Programs, v. 13, no. 7, p. 416.

Brennan, W.J., Hamilton, M., Kilbury, R., Reeves, R.L. and Covert, L., in press, Holocene and late Pleistocene secular variation of the horizontal component of the geomagnetic field in western New York: Earth and Planet. Sci. Letters.

Brigham, A.P., 1898, Topography and deposits of the Mohawk Valley: Geol. Soc. America Bull., v. 9, p. 183-210.

Brigham, A.P., 1908, Fourth report of the director [Mohawk Valley]: N.Y. State Mus. Bull., v. 121, p. 21-31.

Brigham, A.P., 1911, Mohawk glacial lobe (abstract with discussion): Geol. Soc. America Bull., v. 22, p. 725-726.

Brigham, A.P., 1929, Glacial geology and geographic conditions of the lower Mohawk Valley: N.Y. State Mus. Bull., v. 280, 133 p.

Calkin, P., Muller, E.H. and Barnes, J.H., 1982, The Gowanda Hospital Interstadial site, New York: Am. Jour. of Science, v. 282, p. 1110-1142.

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

Chamberlin, T.C., 1888, The rock-scourings of the great ice invasions: U.S. Geol. Survey Ann. Report no. 7, p. 147-248.

Coates, D.S., 1976, Quaternary stratigraphy of New York and Pennsylvania, in Mahaney (ed.), Quaternary stratigraphy of North America: Dowden, Hutchinson and Ross, Inc., Stoudsburg, Pa., p. 65-90.

Connally, G.G. and Sirkin, L.A., 1973, Wisconsinan history of the Hudson-Champlain Lobe, in Black, R.F., Goldthwait, R.P. and Willman, H.B. (eds.), The Wisconsinan Stage: Geol. Soc. America Memoir no. 136, p. 47-70.

Cotter, J.F.P., Ridge, J.C., Evenson, E.B., Sevon, W.D., Sirkin, L. and Stuckenrath, R., in press, The Wisconsinan history of the Great Valley, Pennsylvania and New Jersey, and the age of the "Terminal Moraine".

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

Crowl, G.H. and Sevon, W.D., 1980, Glacial border deposits of Late Wisconsinan age in northeastern Pennsylvania: Pa. Geol. Survey, 4th ser., Gen. Geol. Report G-71, 68 p.

Cushing, H.P., 1905, Geology of the vicinity of Little Falls, Herkimer County: N.Y. State Mus. Bull., v. 77, 95 p.

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

Dreimanis, A. and Karrow, P.F., 1972, Glacial history of the Great Lakes - St. Lawrence region, classification of the Wisconsin(an) Stage and its correlatives: 24th Int. Geol. Congr. Rep. Sect. 12, p. 5-15.

Dreimanis, A. and Goldthwait, R.P., 1973, Wisconsin glaciation in the Huron, Erie and Ontario Lobes, in Black, R.F., Goldthwait, R.P. and Willman, H.B. (eds.), The Wisconsinan Stage: Geol. Soc. America Memoir no. 136, p. 71-106.

Evenson, E.B., Dreimanis, A. and Newsome, J.W., 1977a, Subaquatic flow tills: a new interpretation for the genesis of some laminated till deposits: Boreas, v. 6, p. 115-133.

Evenson, E.B., Mickelson, D.M. and Farrand, W.R., 1977b, Stratigraphy and correlation of the late Wisconsinan glacial events in the Lake Michigan basin: Geogr. Phys. Quat., v. 31, no. 1-2, p. 53-59.

Fairchild, H.L., 1912, The glacial waters in the Black and Mohawk Valleys: N.Y. State Mus. Bull., v. 160, 47 p.

Flick, G.R., in prep., The Pleistocene geology of the Herkimer, New York quadrangle: M.S. thesis, Syracuse Univ., Syracuse, NY.

Foresti, R.J., 1984, Macrofabrics, microfabrics and microstructures of till and Pleistocene geology of the Ilion quadrangle, Mohawk Valley, New York: Unpub. M.S. thesis, Syracuse Univ., Syracuse, NY.

Franzi, D.A., 1984, Till stratigraphy and composition in the western Mohawk Valley region, New York: Ph.D. dissertation, Syracuse Univ., Syracuse, NY, in press.

Frye, J.C. and Willman, H.B., 1973, Wisconsinan climatic history interpreted from Lake Michigan Lobe deposits and soils, in Black, R.F., Goldthwait, R.P. and Willman, H.B., The Wisconsinan Stage: Geol. Soc. America Memoir no. 136, p. 135-152.

Fullerton, D.S., 1971, The Indian Castle glacial readvance in the Mohawk Lowland, New York and its regional implications: Ph.D. dissertation, Princeton Univ., Princeton, NJ, 96 p.

Hicock, S.R., Dreimanis, A. and Broster, B.E., 1981, Submarine flow till at Victoria, British Columbia: Canadian Jour. of Earth Sciences, v. 18, p. 71-80.

Johnson, W.H., 1976, Quaternary stratigraphy in Illinois: status and current problems, in Mahaney, W.C. (ed.), Quaternary stratigraphy of North America: Dowdin, Hutchinson and Ross, Inc., Stroudsburg, Pa., p. 161-196.

Krall, D.B., 1977, Late Wisconsinan ice recession in east-central New York: Geol. Soc. America Bull., v. 88, p. 1679-1710.

LaFleur, R.G., 1969, Glacial geology of the Schoharie Valley, in Bird, J.M. (ed.), Guidebook for field trips in New York, Massachusetts and Vermont: 61st Ann. Mtg., New England Intercollegiate Geol. Conf., SUNY at Albany, Albany, NY, p. 5-1 to 5-20.

LaFleur, R.G., 1979, Wisconsinan stratigraphy in east-central New York (abstract): Geol. Soc. America Abstracts with Programs, v. 11, no. 1, p. 21.

Lawson, D.E., 1979, Sedimentological analysis of the western terminus of the Matanuska Glacier, Alaska: U.S. Cold Regions Research and Engineering Laboratory, Report 79-9, 109 p., Hanover, NH.

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

Lykens, C.A., 1984, Delineating the maximum extent of the Oneida Lobe in the Mohawk Valley: M.S. thesis, Syracuse Univ., Syracuse, NY, 88 p.

May, R.W., 1977, Facies model for sedimentation in the glaciolacustrine environment: Boreas, V. 6, p. 175-180.

Miller, W.J., 1909, Ice movement and erosion along the southwestern Adirondacks: Am. Jour. Sci. (4), v. 27, p. 289-298.

Mörner, N.-A. and Dreimanis, A., 1973, The Erie Interstade, in Black, R.F., Goldthwait, R.P. and Willman, H.B. (eds.), The Wisconsinan Stage: Geol. Soc. America Memoir no. 136, p. 107-134.

Muller, E.H., 1965, Quaternary geology of New York, in Wright, H.E., Jr. and Frye, D.G. (eds.), The Quaternary of the United States: Princeton Univ. Press, Princeton, NJ, p. 99-112.

Muller, E.H., 1966, Glacial geology and geomorphology between Cortland and Syracuse: Nat. Assoc. Geol. Teachers, Eastern section, Field trip guidebook, Cortland area, p. 1-15.

Muller, E.H., 1977, Quaternary geology of New York, Niagara sheet: N.Y. State Mus. and Science Service, Map and Chart Series, no. 28.

Muller, E.H., Franzi, D.A. and Ridge, J.C., in review, Pleistocene geology of the western Mohawk Valley, New York.

Rich, J.L., 1935, Glacial geology of the Catskills: N.Y. State Mus. Bull., v. 299, 180 p.

Ridge, J.C., in prep., Late Wisconsinan glacial history and secular variation of magnetic declination in the lower West Canada Valley of central New York: Ph.D. dissertation, Syracuse Univ., Syracuse, NY.

Rust, B.R. and Romanelli, R., 1975, Late Quaternary subaqueous outwash deposits near Ottawa, Canada, <u>in</u> Jopling, A.V. and McDonald, B.C. (eds.), Glaciofluvial and glaciolacustrine sedimentation: Soc. Econ. Paleontologists and Mineralogists, Spec. Pub. no. 23, p. 177-192.

Vanuxem, L., 1842, Geology of the third district: Nat. Hist. of New York, Albany, NY, 306 p.

Wright, H.E., Jr., Matsch, C.L. and Cushing, E.J., 1973, Superior and Des Moines Lobes, <u>in</u> Black, R.F., Goldthwait, R.P. and Willman, H.B., The Wisconsinan Stage: Geol. Soc. America Memoir no. 136, p. 153-185.

ROAD LOG

The field trip log starts at the intersection of Rt. 28 and Rt. 5 in downtown Herkimer where Rt. 28 heads north to Middleville (see Figure 14). To reach Herkimer head north from Clinton on Rt. 12B to Utica. In Utica, follow Rt. 5 to Herkimer or take the NY State Thruway - Rt. 90 (toll) east to the Herkimer exit. In Herkimer follow signs for Rt. 28.

Assemble at 8:30 A.M. in the parking lot of Chicago Market and Carls Drugs at the intersection of Rts. 5 and 28 in eastern downtown Herkimer

Miles	Route Description
0.0	From intersection of Rts. 5 and 28 in eastern downtown Herkimer (Herkimer quadrangle) head north on Rt. 28 toward Middleville and Newport.
3.0	Kast Bridge. The course of West Canada Creek has been staightened in this section of the valley. Note the flat topped bluff on east bank of West Canada Creek.
3.4	Bluffs on left side of highway (to west) expose Holland Patent and Norway tills. North Creek enters West Canada Creek from the east. West Canada till and striations on bedrock of the Trenton Group (N60W) are exposed along the last mile of North Creek before it enters West Canada Creek.
3.7	Bluffs on east bank of West Canada Creek expose units from Holland Patent till at the top through Norway and Hawthorne tills to West Canada till at the base. The bluffs are typical of many high banks along West Canada Creek between Kast Bridge and Middleville. These bluffs do not exist on the west bank of West Canada Creek because of the asymmetry of the bedrock profile of the valley. The apparent flat-topped surfaces of the bluffs are capped by till and lacustrine sediments. The flat benches may be the result of initial fluvial downcutting in the valley or the floors of lakes that existed during recession of the Barneveld Readvance.
7.1	Enter Middleville quadrangle.
7.3	View of STOP 1 from KOA campground. Bluff on east bank of West Canada Creek (Section 9 on Figure 3). Ahead on left are commercial Herkimer "diamond" (more appropriately

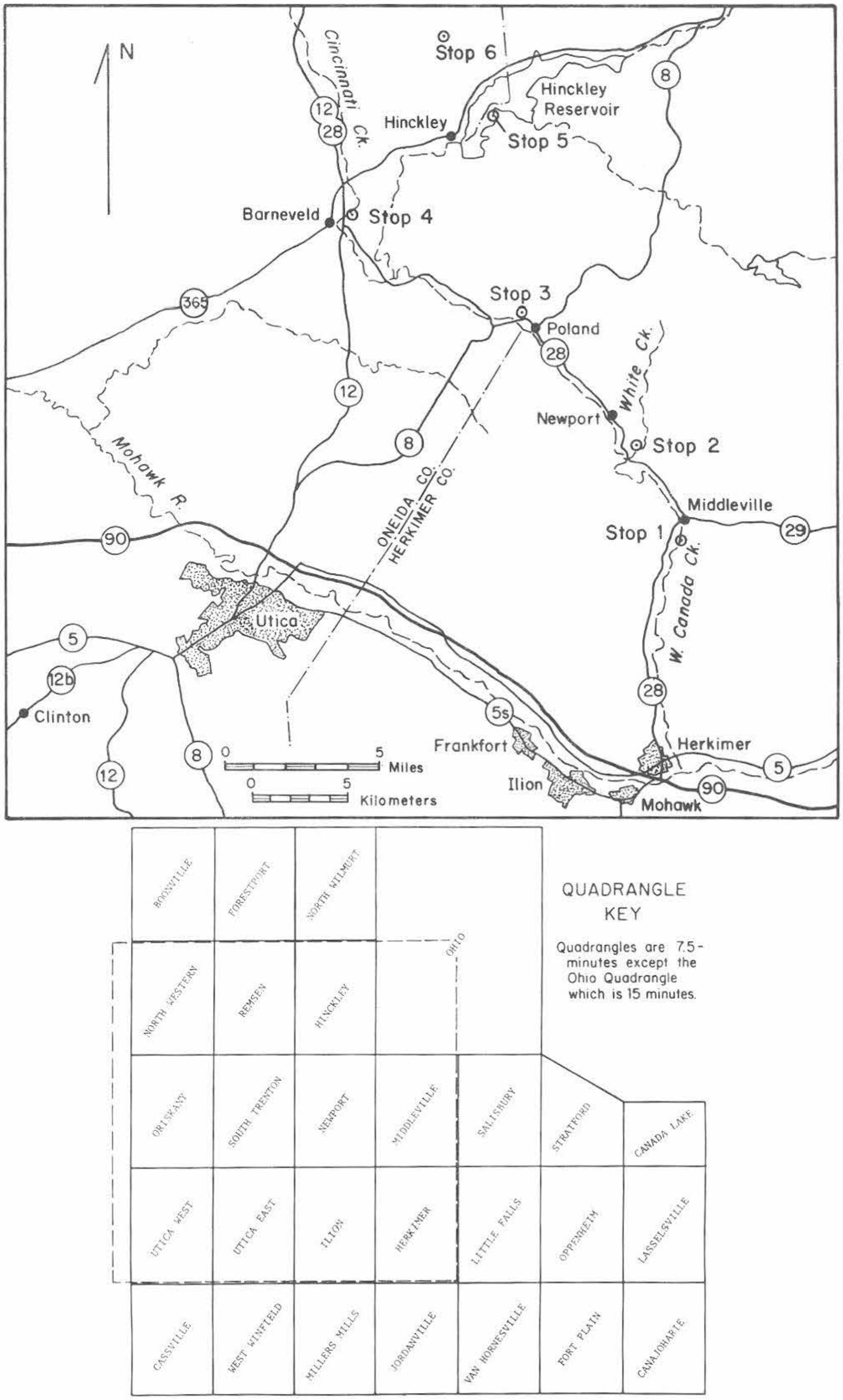

Figure 14. -- Highway map showing field trip stops. Key to USGS quadrangle maps covered by Figures 1 and 8, 9 and 11 thru 13. Dashed line shows area covered by highway map.

Middleville "diamond") prospecting grounds.

7.7 Exposures of Little Falls Dolostone on left while entering town of Middleville.

8.1 Turn right (east) staying on Rt. 28 in Middleville and proceed across bridge over West Canada Creek.

8.3 Traffic light at intersection of Rts. 28, 29 and 169 in Middleville. Turn right at light onto Rt. 169.

8.75 STOP 1. Park vehicles on shoulder of Rt. 169 next to entrance to pasture on right. Walk on dirt road to right to top of hill and across pastures for 0.5 miles to West Canada Creek bluff exposure.

Features and topics for discussion: (Section 9 on Figure 3)

1) Lithology and genesis of unit equivalent to the Norway till.

2) Lithologic and provenance changes within lacustrine sediment between the Norway till equivalent and the Hawthorne till.

3) Nature of contact of Hawthorne till and upper Newport beds.

4) Transition from upper Newport beds to West Canada till.

5) Compact and stony character of West Canada till.

6) Paleomagnetic samples were taken from the upper Newport beds and from three levels within the lacustrine sediments between the Norway till equivalent and the Hawthorne till.

Return to vehicles and head back to Rt. 28 via Rt. 169.

9.2 Junction of Rts. 28, 29 and 169. Continue north (straight) through Middleville on Rt. 28.

9.8 Terrace along West Canada Creek. Many terraces in the valley are graded to lake levels in the lower West Canada and Mohawk valleys (Figure 13). They contain alluvial fan sediment and slope away from large gullys cut in the glacial deposits along the valley sides.

10.2 Right side of Rt. 28 and continuing for the next 1.5 miles are outcrops of Little Falls Dolostone. Behind the exposure on the right is a large quarry noted for its Herkimer "diamonds".

11.6 Junction of Rt. 28 and White Creek Rd. on right. On left is West Canada Valley Central School. Turn right onto White Creek Rd. which parallels White Creek.

12.0 STOP 2. Park vehicles and walk across pasture on west side of White Creek Road.

Features and topics for discussion: (Section 5 on Figure 3)

1) Upper Newport beds appear at top of bluffs in soil profile.

2) Clayey and silty character of West Canada till.

3) Deformation of lower Newport beds beneath West Canada till. Nappe-like folds and thrusts with northwest directed displacement.

4) Transition from lower Newport beds to White Creek till and associated sediment flows.

5) Topography on the upper surface of the White Creek till (morainic or drumlinoid features or neither?).

6) Very stony character of the White Creek till which contains a high proportion of metamorphic clasts.

7) Subglacial grooving on the surface of the White Creek till has been exposed here in the past.

Return to vehicles and head back to Rt. 28 via White Creek Rd.

12.4 Junction of White Creek Road and Rt. 28. In view to the west-southwest from this intersection is a large bluff on the west bank of West Canada Creek (Section 6 on Figure 3). This section contains all the units from the lower Newport beds to the Norway till on top. Turn right (west) onto Rt. 28 toward Newport.

12.45 Enter Newport quadrangle.

12.7 Cross White Creek.

12.9	Right side of highway. Bluff exposure of Hawthorne till overlying upper Newport beds.
13.5	Right side of highway. Old meander scar of West Canada Creek. Across pasture are bluff and gully exposures (Sections 3 and 4 on Figure 3) which contain all units from basal White Creek till up thru Norway till.
13.8	Enter town of Newport and continue northwest on Rt. 28.
15.0	Leave Newport and head west toward Poland on Rt. 28.
16.3	Right side of highway. Lacustrine sands which lie stratigraphically below the Norway till and may predate or be time-equivalent to the Hawthorne till and Salisbury Readvance.
17.2	Fluvial terrace on right is inset in an older alluvial fan which slopes toward the center of the valley from large gullys to the northeast.
17.4	Enter Poland.
18.1	Center of Poland. Junction of Rts. 28 and 8. Stay on Rt. 28 to the northwest.
18.6	Turn off Rt. 28 onto dirt road leading into gravel pits.

STOP 3. Poland sand and clay pits.

Two exposures:

1) Pit exposing outwash sands. Fluvial sand infilling early incision of the valley cut during fall in lake levels proceeding the Barneveld Readvance.

2) Clay pit exposure of Phase II sediments.

Section: (similar to Sections 1 and 2 on Figure 3 and northwest end of West Canada Valley profile on Figure 7)

(top)

6 ft.	oxidized varves (soil profile)
1 ft.	sediment flows

6 ft.	clayey dark gray till with high proportions of sandstone and Trenton Group limestone clasts (Norway till)
1 ft.	deformed lacustrine beds
4 ft.	thin varve couplets (less than 2 inches) containing a pink and tan clay component and red rain-out sediment (Oneida Sublobe provenance); flutes indicate paleocurrent flow to the southeast.
12 ft.	thick varve couplets (greater than 2 inches) with dark gray and drab colors and black rain-out sediment near base (Mohawk Sublobe provenance); couplets thicken downward; rib and furrow structures indicate paleocurrent flow to the northwest.
2 ft.	lacustrine sand and silt, oxidized at top and contain calcareous cement.
25 ft.	rippled lacustrine sands with calcareous cemented layers and lenses; paleocurrent flow to the east.

(limit of exposure)

Note especially change from Mohawk to Oneida Sublobe provenance within the varve section accompanied by a change in paleocurrent directions from northwest to southeast.

Return to Rt. 28 and head north.

18.8	Cross West Canada Creek.
19.0	Flat-topped hill to right with gravel pit excavations is capped by an ice-marginal delta at the maximum position of the Barneveld Readvance.
19.5	Intersection of Rts. 8 and 28. Stay on Rt. 28 to the right. Cross bridge over West Canada Creek.
21.6	Cross Mill Creek on Rt. 28.
21.8	Enter South Trenton quadrangle.
22.4	Cross West Canada Creek.
22.6	Enter Remsen quadrangle.

23.3	Cross Cincinnati Creek.
24.5	Main road bears to the left. Continue on Rt. 28 to the left.
25.35	Intersection of Routes 12 and 28. Proceed north on Rt. 12 toward Barneveld.
25.7	Railroad underpass.
25.8	Turn left off Rt. 12, follow signs to Barneveld.
26.5	Intersection with Rt. 365 in Barneveld. Proceed east (right turn).
26.9	Rt. 12 underpass.
27.4	STOP 4. Park vehicles at side of road. Cincinnati Creek sections (Figure 5).

Return to vehicles and continue northeast from STOP 4.

28.2	Intersection with Rt. 365. Proceed northeast on Rt. 365 (right turn) through railroad underpass.
30.9	The highway crosses an incised portion of a delta deposited during recession from the Hinckley Readvance.
31.3	Enter Hinckley quadrangle.
31.6	Hills on both sides of the highway are a part of the Hinckley Moraine System.
31.9	Enter village of Hinckley. Turn right (south) onto bridge crossing West Canada Creek.
32.3	Main road bears left.
32.7	Hinckley Dam
35.0	Main road bears right. Leave main road proceeding north (straight ahead) and follow signs to Trail's End Park. DO NOT ENTER PARK. Exposure on the east side of the road contains calcareous western provenance gravel overlying older non-calcareous gravel of Adirondack provenance.
35.1	STOP 5. Dirt driveway leading to Trail's End bluff exposure on Hinckley Reservoir (Figure 10). NOTE: This is private property.

Follow route of field trip back to Hinckley.

38.2 Intersection with Rt. 365 at Hinckley. Follow one of two options.

Option 1. Follow Rt. 365 west (turn left) to Rt. 12 south and terminate field trip. Distance to Rt. 12 from Hinckley is 6.1 miles.

Option 2. Follow Rt. 365 east (turn right) and proceed to STOP 6.

38.5 Hinckley Dam

40.8 Village of Ninety Six Corners. Turn left off Rt. 365 and proceed northwest toward Bailey Hills.

42.4 STOP 6. Bailey Hills delta. Follow dirt road into gravel pit.

Return to vehicles and continue west.

42.5 Enter Remsen quadrangle. On both sides of the road is hummocky topography resulting from stagnation of the Black River Sublobe as it thinned over the Black River-West Canada Creek divide during recession from the Hinckley Readvance. The drift is composed of both stratified deposits and ablation till.

44.6 Intersection near Fairchild Cemetary. Continue west.

46.0 Road ends at "T" intersection. Turn left and proceed south into Remsen.

47.1 Intersection in village of Remsen. Turn right and proceed west to Rt. 12.

47.5 Junction with Rt. 12. Proceed south and follow signs to Utica and Clinton.