GLACIAL GEOLOGY OF THE ERIE LOWLAND AND ADJOINING ALLEGHENY PLATEAU, WESTERN NEW YORK

PARKER E. CALKIN - Department of Geological Sciences, State University of New York, Buffalo, NY 14226

GEOMORPHIC SETTING

The Allegheny section of the Appalachian Plateau (Allegheny Plateau) in western New York may be divided into three physiographic areas; from the Pennsylvania border northward, these include: 1) the high and rugged, unglaciated Salamanca Re-entrant, south of the Allegheny River; 2) the glaciated southern New York Uplands with rounded summits and a network of "through valleys" and breached drainage divides (Cole, 1941; Muller, 1963); and 3) the Erie County portion north of the east-west Cattaraugus Valley. This area is furrowed by deep parallel north-trending troughs separated by broad interfluves and strongly developed to accommodate glacier flow (Donahue, 1972, Calkin and Muller, 1980). Bordering on the west and north, respectively, are the Erie and Ontario lowlands blanketed by glaciolacustrine and ice contact drift, and traversed by subdued, waterlaid end moraines. The Erie County portion of the plateau and the Lake Erie Lowland are the areas spanned by the accompanying field trip log (Fig. 1).

At the close of Paleozoic sedimentation in the Appalachian geosyncline (see Frontispiece I) and prior to glaciation, the area underwent epeirogenic uplift and gentle southward tilting of about 8 m km^{-1} (40 ft mi^{-1}. Initial southward consequent drainage on this surface was eventually reversed to a northwesterly obsequent system and episodic uplift resulted in deep entrenchment of these north-flowing rivers (Calkin and Muller, 1980). The most prominent drainage lines headed south of the present Cattaraugus Valley and included from west to east: 1) the preglacial Allegheny, flowing westward past the Salamanca Re-entrant and northward through Gowanda to Lake Erie along the path of the present Conewango and lower Cattaraugus valley (Ellis, 1980; Frontispiece II); 2) the Connisarauley and 3) the Buttermilk rivers (LaFleur, 1979; D. Hodge, personal communication, 1980) which flowed northward along the present paths of South and North Branches, respectively, of Eighteenmile Creek (Fairchild, 1932); and 4) the Preglacial Cazenovia River (Calkin and others, 1974) which extended 70 km (43 mi) northward from Ischua near the east edge of the Re-entrant, through the present East Branch Cazenovia Creek and East Aurora toward Buffalo (Frontispiece II).

GLACIATION OF THE ALLEGHENY PLATEAU

The Southern Uplands Area and Pre-Lake Escarpment Glaciations

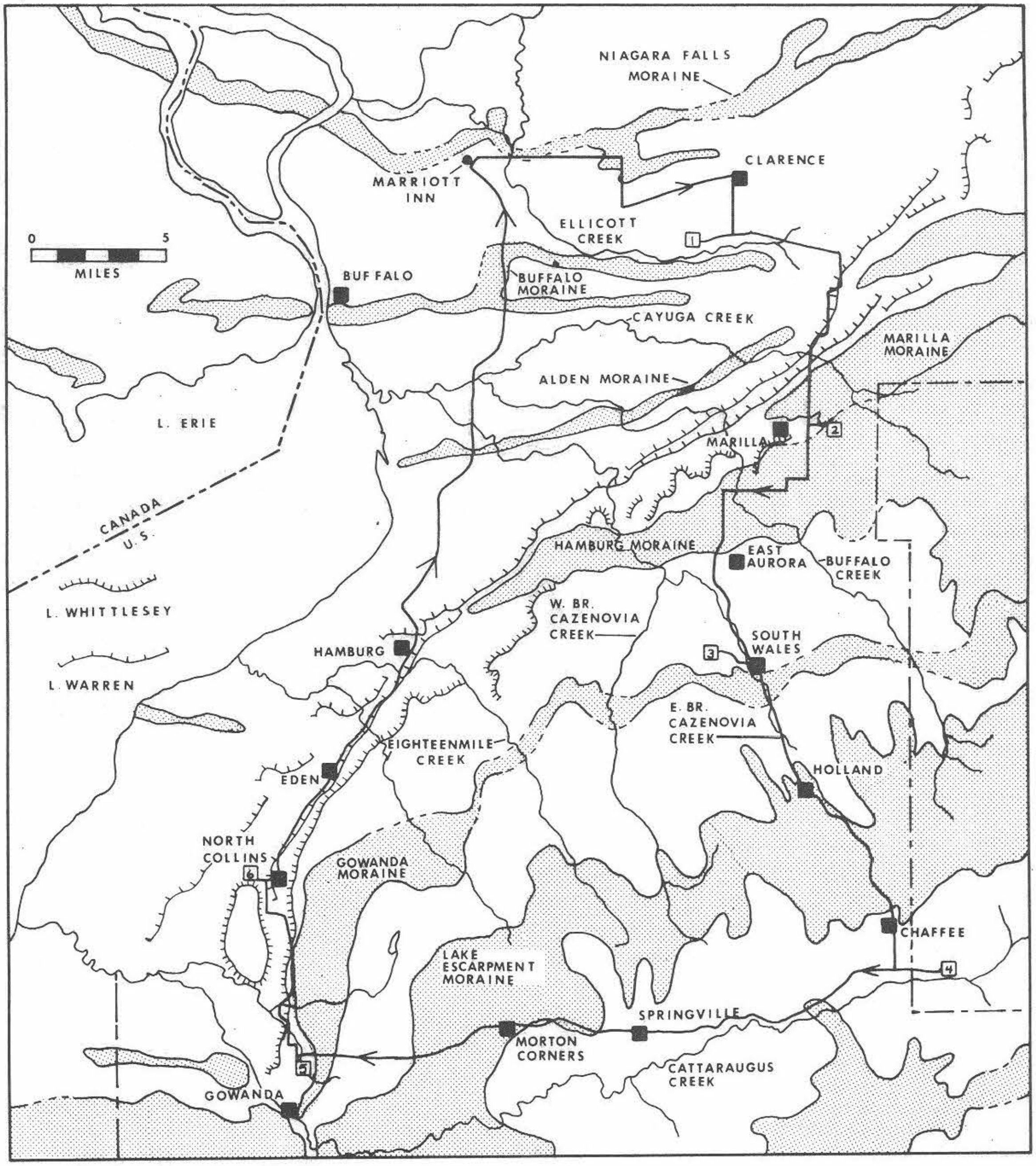

Figure 1. Map of Erie County, New York showing major end moraines, strand lines of the major Glacial Great Lakes, and the field trip route with stops.

Ice sheets moving through the Erie and Ontario troughs abutted repeatedly against the Salamanca Re-entrant (MacClintock and Apfel, 1944; Frontispiece II). Weathered till and gravel spotted around the margins may be of Illinoian age and represent the only pre-Wisconsin drift exposed in New York. However, several events suggest a longer history of multiple glaciation. One of the more interesting is the impondment and diversion of the Allegheny River to its present southerly path to the Ohio River (Muller, 1975; Philbrick, 1976). A second major change in topography appears to be the product of ice marginal superposition and entrenchment which allowed Cattaraugus Creek (Frontispiece II and Fig. 1) to cut westward to Lake Erie across the Tertiary north-trending valley system (Fairchild, 1932; Calkin and others, 1974).

Several drift sheets have been distinguished across western New York (Fig. 2; Muller, 1975, 1977a; LaFleur, 1979, 1980; Calkin and others, 1982). Frontispiece II, at the beginning of this guidebook, shows the major end moraines distinguished. The oldest drift ends southward at the Olean Moraine, the Wisconsin terminal along the northeastern side of the Salamanca Re-entrant. MacClintock and Apfel (1944) considered this end moraine to be more deeply weathered and topographically subdued than the terminal moraine on the northwestward flank of the Re-entrant which is assigned to the younger Kent Drift. The drab, Olean Drift is presently correlated with a Middle Wisconsin advance (Muller, 1977a; Calkin and others, 1982) based on subsurface stratigraphic relations (see below) tied to events near Titusville, Pennsylvania (Chapman and Craft, 1976). Other geologists tracing the Wisconsin drift border northward from Pennsylvania have correlated the Olean with the Late Wisconsin (Crowl, 1980).

The Kent Moraine and associated drift to the north and west displays prominent topography with relatively fresh unweathered deposits often characterized by large percentages of far-traveled stones in the lowlands (LaFleur, 1980). Far-traveled (exotic) stones typically include crystalline rocks transported from the Canadian Shield and tough red, green or gray sandstones and carbonate rocks derived from the Niagara escarpment area. Gadd (1981) has recognized purple-weathered anorthosite boulders in the Cattaraugus Basin that appear to be derived from areas northeast of Montreal. The Kent Moraine marks the maximum advance of the Late Wisconsin (Muller, 1977a) and its age can be bracketed by radiocarbon dates. The advancing ice margin had not crossed the buried St. Davids Gorge of the Niagara by 22,800 yr B.P. (Hobson and Terasmae, 1969; Calkin and Wilkinson, 1982, this volume) nor Rush Creek in the Genesee Basin at 25,300 yr B.P. (Muller and others, 1975) but had reached its maximum throughout the Erie Basin by 20,000 yr ago (Dreimanis and Goldthwait, 1973).

Multiple till exposures and subsurface data at the Gowanda Hospital and at Otto interstadial sites in southwestern New York (Frontispiece II and Figs. 1-3) provide evidence of extensive Early Wisconsin glaciation followed in Middle Wisconsin time by a long, cool interstadial before the Kent glaciation (Muller, 1964; Calkin and others, 1982). At Gowanda

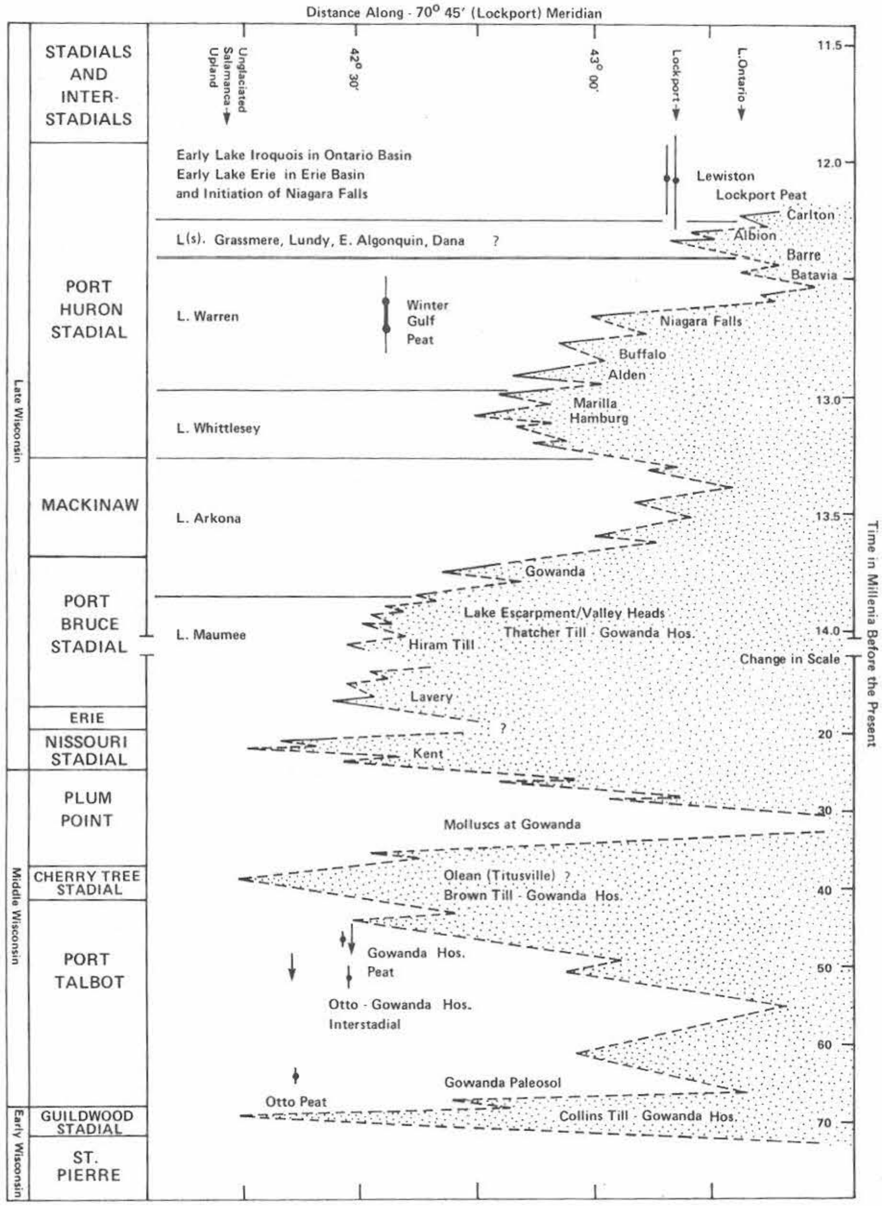

Figure 2. A working chronology of Wisconsin glacial events in western New York. Modified after Muller (1977a).

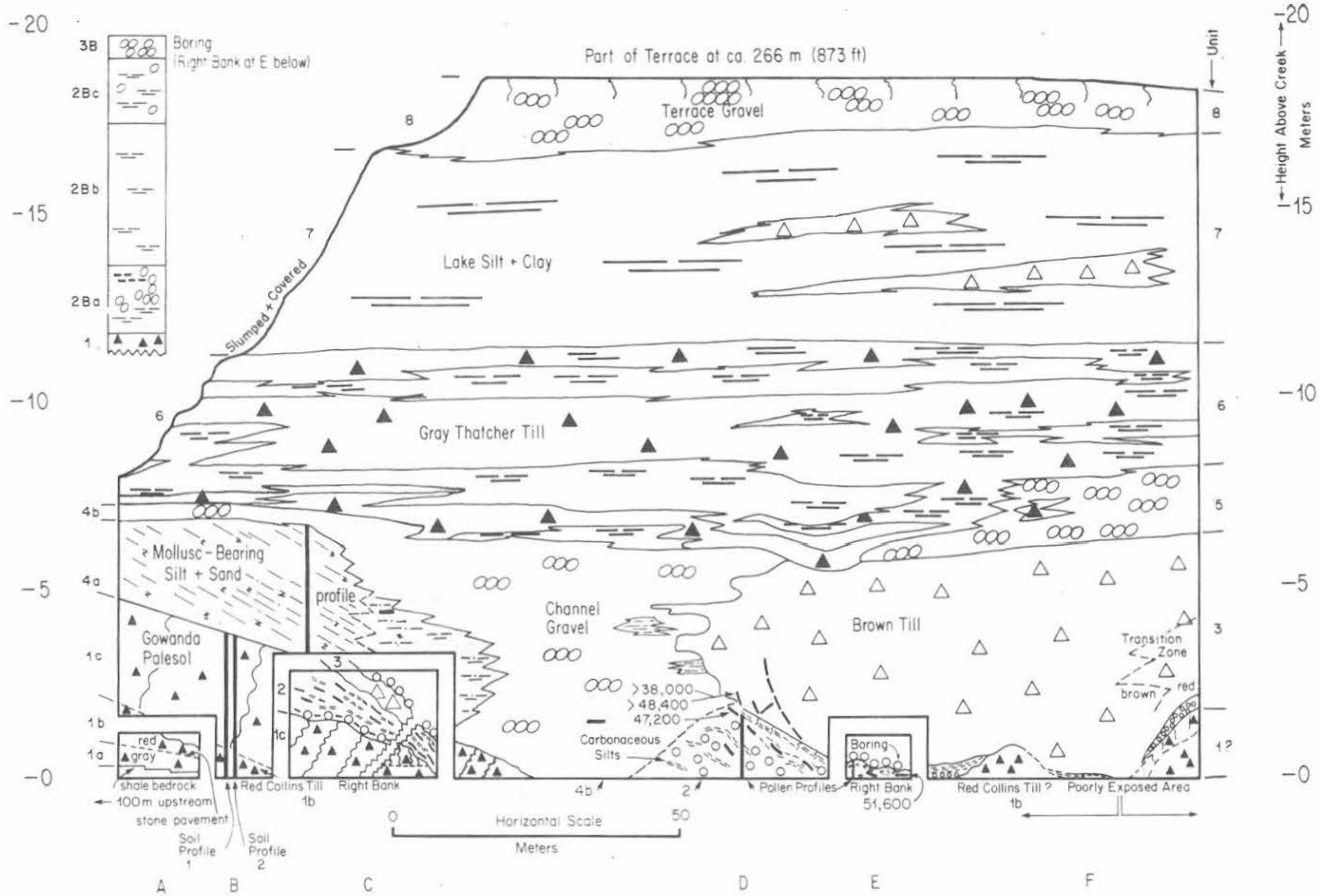

Figure 3a. Composite stratigraphic section along right and left banks of Clear Creek at the Gowanda Hospital Interstadial Site, Erie County, N.Y. From Calkin and others (1982).

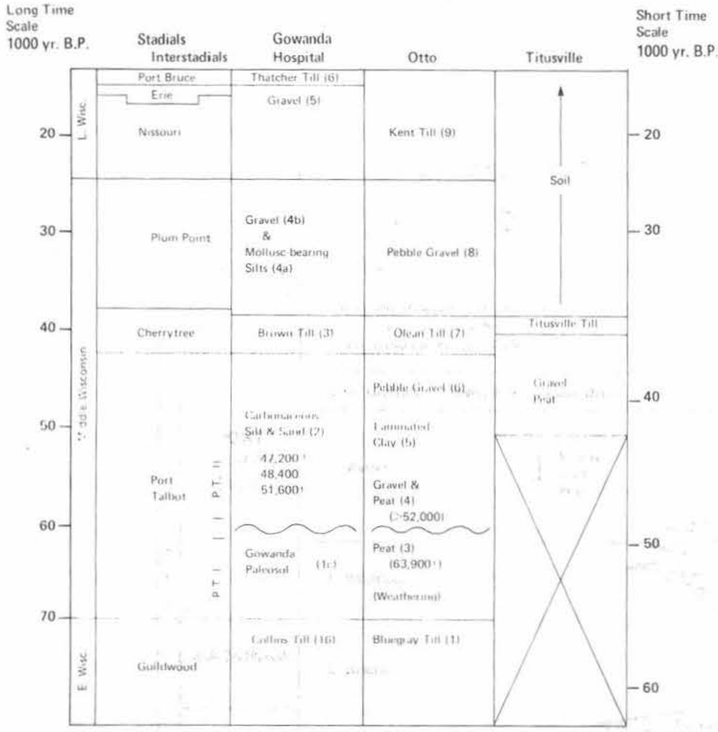

Figure 3b. Correlation of stratigraphic sections at the Gowanda Hospital and Otto interstadial sites, N.Y., and a section at Titusville, Pennsylvania. Modified after Calkin and others (1982).

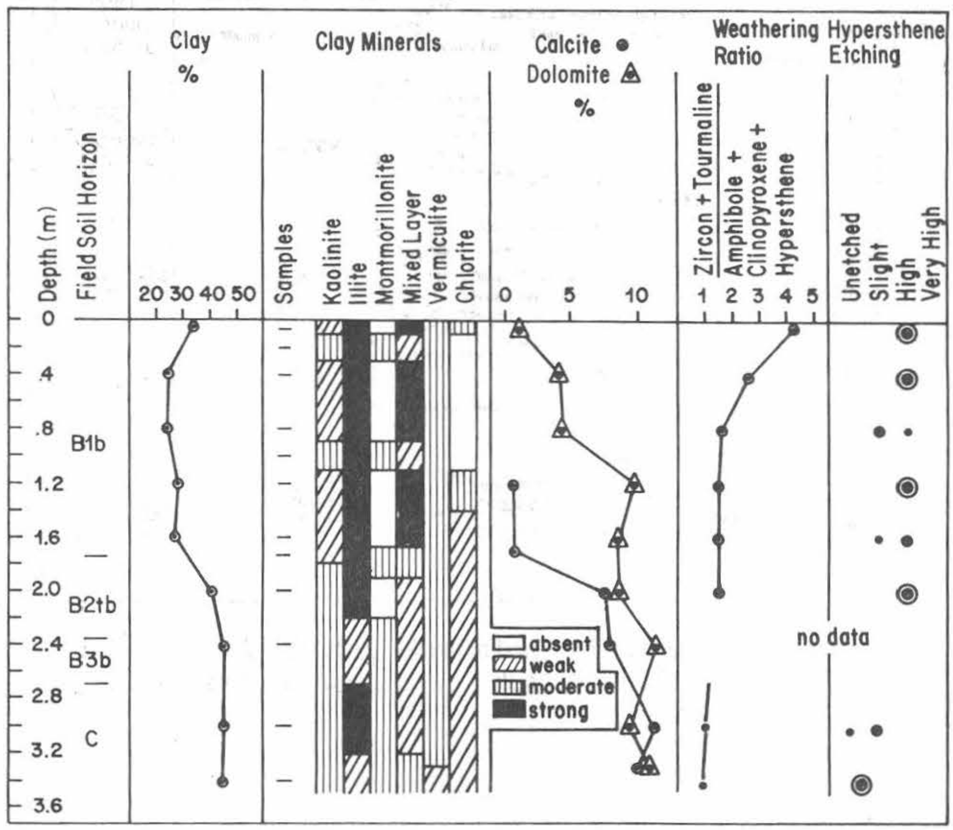

Figure 3c. Properties of the Gowanda Paleosol with: clay % < 2000 µm; clay mineral variation with depth expressed as indication of mineral presence; calcite and dolomite % of < 63 µm fraction; heavy mineral ratio for indicated depths relative to that for lowest two samples (3.0 and 3.4 m); and etching of three grains per sample. From Calkin and others (1982).

Hospital (Fig. 3), a red till (named the Collins Till) derived from a southwestward-moving ice lobe, bears a deep soil profile (Gowanda Paleosol). This is overlain in turn by gravelly organic silt, a brown basal till which incorporates some of the silt, and gravel bearing a terrestrial mollusc assemblage indicative of cold forest-tundra conditions and free drainage. The organic silt carries a spruce-rich pollen spectrum and wood radiocarbon-dated to a probable finite age of 51,000 yr B.P. This sequence is correlated (Fig. 3b) with a similar one at the Otto site (Muller, 1964) and with the eastern Great Lakes glacial chronology on the basis of ^{14}C dates and pollen data (Calkin and others, 1982).

Following the Kent glaciation and during the succeeding interval correlated with the Erie Interstade, the ice front retreated from southwesternmost New York and possibly northward into the Ontario Basin allowing formation of Lake Leverett in the Erie Basin (Morner and Dreimanis, 1973; Fullerton, 1980, note 29). LaFleur (1979, 1980) has described subaerial erosion surfaces and stream gravels in the upper Cattaraugus Valley that seem to support this retreat as well as lowering of baselevel to near that of the present Lake Erie.

Clayey tills which overlie the "typical" Kent drift along the Plateau margin in Chautauqua County (Muller, 1963) as well as farther east in the Cattaraugus Basin (Fig. 4), have tentatively been correlated with the Lavery and succeeding Hiram drifts of Ohio and Pennsylvania (Fig. 2; Muller, 1963, 1975, 1977a). These represent major glacial readvance with uptake of clay from proglacial lakes developed in the Erie Lowland or north-draining plateau troughs during the preceding retreat. The thick Lavery tills of LaFleur (1979, 1980) form the burial medium at the former nuclear fuels reprocessing plant in West Valley.

The Lake Escarpment Glaciation

South of the Village of Gowanda, and along the drainage divide north of Cattaraugus Creek are the very massive gravelly ridges, of Leverett's (1902) Lake Escarpment Moraine System (Frontispiece II, Fig. 1). These mark an oscillating stand of the ice margin behind the position of the Lavery and Hiram moraines and resulted in deposition of the Thatcher Till of western New York (Calkin and others, 1982). The Lake Escarpment Moraine is referred to as the Ashtabula Moraine in western Pennsylvania and Ohio (Muller, 1963; White and others, 1968) and is correlative with the equally massive Valley Heads Moraine System in central New York (Muller, 1977a, 1977b).

During the Lake Escarpment glaciation, pitted outwash plains built southward into the Cattaraugus Basin, over valley fills that are up to 200 m thick in the northeast-trending (buried pre-glacial) valleys at Chaffee and Springville. The outwash was graded to a series of proglacial lakes (Fairchild, 1932; Calkin and Miller, 1977; Calkin and McAndrew, 1980) that drained west along the ice margin into the Coneweango Valley (buried preglacial Allegheny) and thence to the Allegheny River.

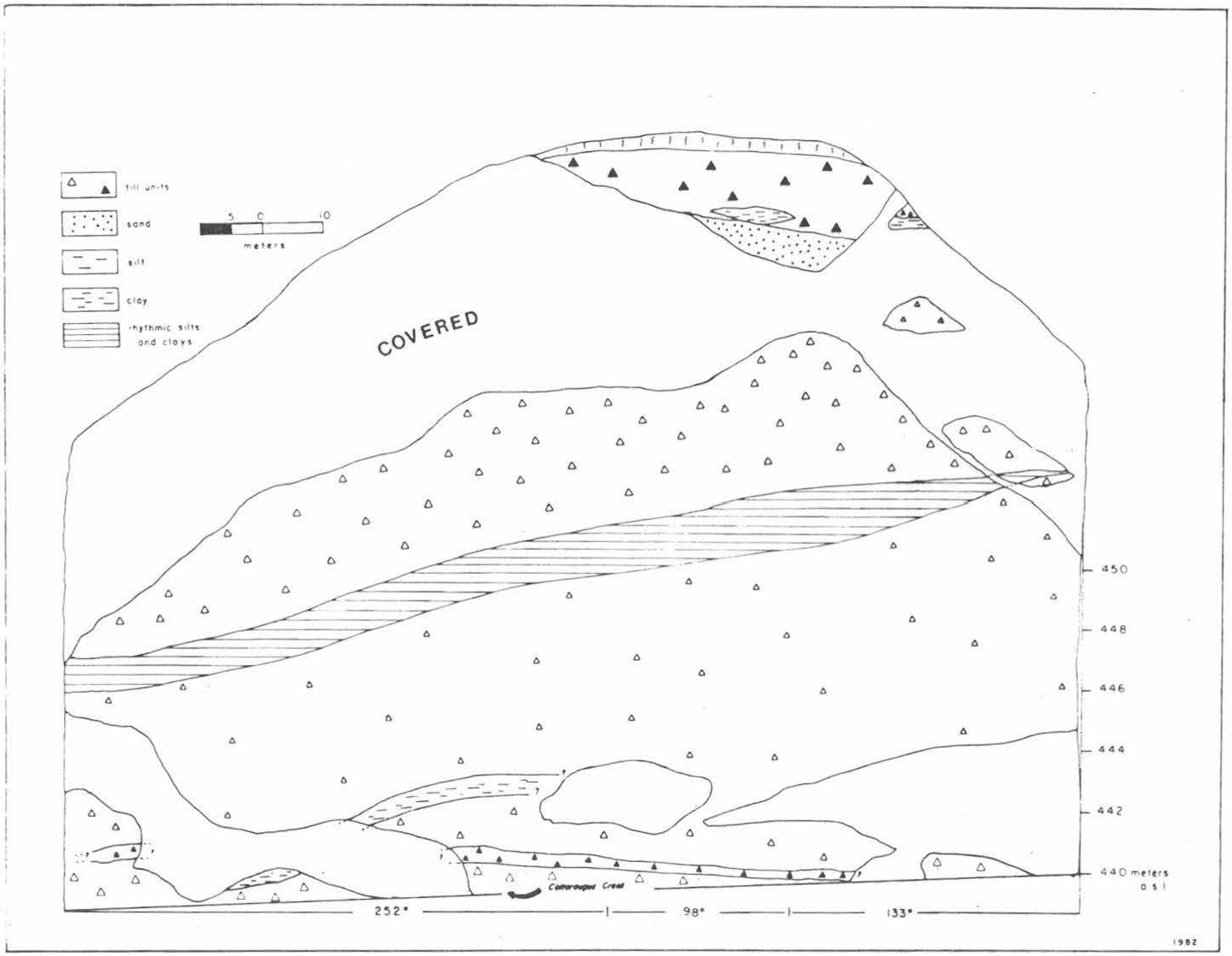

Figure 4. Stratigraphic section at the Arcade Site on Cattaraugus Creek. By Brenda Gagné, 1982).

Peat deposited directly on outwash at a mastodon locality along Nichols Brooks near Chaffee (Frontispiece II and Fig. 1) was considered to closely post date ice retreat when a basal peat date of 14,900 yr B.P. was obtained (Calkin and McAndrews, 1980). However, more recent resampling and study seems to confirm earlier suspicions that the dated peat included recycled (old) carbon and was too old by about 2000 yr (A. Morgan, pers. comm., 1982). Nevertheless, retreat on the order of 14,000 yr B.P. would be compatible with radiocarbon dates obtained from just south of the Valley Heads Moraine System to the east (Coates and others, 1971; Brennen, personal communication, 1981). The pollen at the Nichols Brooks Site indicated an open boreal spruce woodland vegetation without tundra; Morgan and Morgan (1977) have reported permafrost conditions recorded in adjacent Ontario at about 14,000 yr B.P.

A succession of short-lived proglacial lakes formed partly in the valleys trending northwestward from Chaffee, Springville, and Morton Corners. Initially, these drained southward cutting channels through the Lake Escarpment ridges and outwash into proglacial lakes of the Cattaraugus Valley. However, with continued ice retreat, these finger lakes spilled westward across the interfluves, cutting channels and building massive kame and lacustrine deposits (Owens and others, 1972; Hollands, 1975; Pryor, 1975) en route to a concurrently expanding glacial Great Lake in the Erie Basin (Calkin and Miller, 1977).

A longer pause in retreat and short readvance following the strong Lake Escarpment oscillation, is marked by the Gowanda Moraine (Fig. 1), a low but distinct ridge apparently tied closely to the Lake Escarpment ridges which extend between South Wales, North Collins, and the Lake Erie coast at Dunkirk (Frontispiece II). Unpublished geophysical exploratory data along the Lake Erie coast suggest possible correlation of the Gowanda with the Erie-Long Point (Norfolk) Moraine across Lake Erie. Retreat across western New York at this time is correlated with the Port Bruce Stadial or MacKinaw Interstadial on the basis of continuity of events across the eastern Great Lakes (Calkin and Miller, 1977; Fullerton, 1980). The marginal drainage was probably into Glacial Lake Arkona (Fig. 2) although no definitive Arkona strand lines have yet been traced north of Girard, Pennsylvania (Calkin, 1970; Schooler, 1974; Fullerton, 1980). The ice margin continued retreat north and eastward out of the Erie into the Ontario Basin and for a period of a few hundred years or less, lake levels fell considerably below the Arkona level, possibly allowing waters to drain northward across the Niagara Escarpment and eastward from the Ontario Basin through the Syracuse channels (Wall, 1968; Fullerton, 1980).

GLACIATION OF THE ERIE LOWLAND

Glacial Lakes and Ice Margins

At least ten stages of proglacial Great Lakes may be recorded in the New York portion of the Erie Basin during Late Wisconsin time (Fig. 2); however, only the highest, Lake Whittlesey, and two stages of the succeeding Lake Warren produced strand lines strong and continuous enough to be traced south or westward out of New York to type areas. Both Whittlesey and Warren Lakes stretched up to 480 km (298 mi) southwest from Buffalo to beyond Toledo, Ohio. These are believed to have been controlled by west-draining outlets through Michigan (Hough, 1963, 1966; Calkin, 1970; Muller, 1977a).

The Mackinaw Interstadial was terminated by the Port Huron advance in Michigan and in western New York, inducing a rise in glacial waters through at least 12 m (40 ft) to the Glacial Lake Whittlesey level in the Erie-Huron basins and the resubmergence of the Erie Lowland in western New York. A unit of glacial varved clay and thick superimposed basal till traced through several exposures along 32 km (20 mi) of Lake Erie bluff between South Buffalo and the Hamburg Moraine may record this advance. These relations and those elsewhere including at the Winter Gulf organic site (Fig. 5; Calkin, 1970; Calkin and McAndrews, 1980) suggest that the ice margin reached to, if not locally beyond, the massive Marilla Moraine or adjacent closely associated Hamburg Moraine (Frontispiece II; Fig. 1). If it reached much farther and into the Plateau to build or override the Gowanda Moraine (Taylor, 1939; Calkin and Miller, 1977) the ice must have been thin and the advance short-lived before recession to construct the Hamburg Moraine. Fullerton (1980) has linked the Port Huron advance with the Alden Moraine in New York but local field relations as presently interpreted do not appear to support this correlation. In southern Ontario, the Port Huron advance has been correlated with the margin of the Halton Till (Barnett, 1979; Feenstra, 1981) which occurs 20 to 30 km (12.4 to 18.6 mi) beyond the position of the submerged Port Maitland Moraine.

The strand of Glacial Lake Whittlesey is the strongest and most continuous of those in New York; it occurs principally as a single distinct gravel storm beach ridge of ∿6 m (20 ft) relief. However, pronounced beaches cut in bedrock are associated with the Whittlesey beach ridge in the villages of North Collins, Eden, and Hamburg (Calkin, 1970). The strength of the Whittlesey strand line must be a consequence of formation by rising waters and its location near a plentiful gravel supply at the plateau margin as well as the duration of the lake stand. The Lake Whittlesey strand line reaches its northern and easternmost expression near Marilla where weak, wave-cut features at an elevation of 277 m (910 ft) occur on the north flanks of the Hamburg Moraine. This and other relations (Calkin, 1970; Muller, 1977b) suggest that the Marilla Moraine was formed in Lake Whittlesey; however, lowering of Lake Whittlesey waters to Lake Warren I must have occurred during or soon after retreat from the Marilla Moraine (Calkin, 1970).

The strong development of beaches of all stages of Lake Warren on the north face of the Marilla Moraine indicate that at least 5 to 10 km of retreat occurred before renewed downcutting of Lake Warren's Grand River outlet in Michigan caused water levels to fall to the Lake Warren II level. Warren I and II strand lines as distinguished in western New York terminate in spits in the delta of Ellicott Creek, 5 km northeast of Alden and just south of the Alden Moraine (Fig. 1). A drop in lake

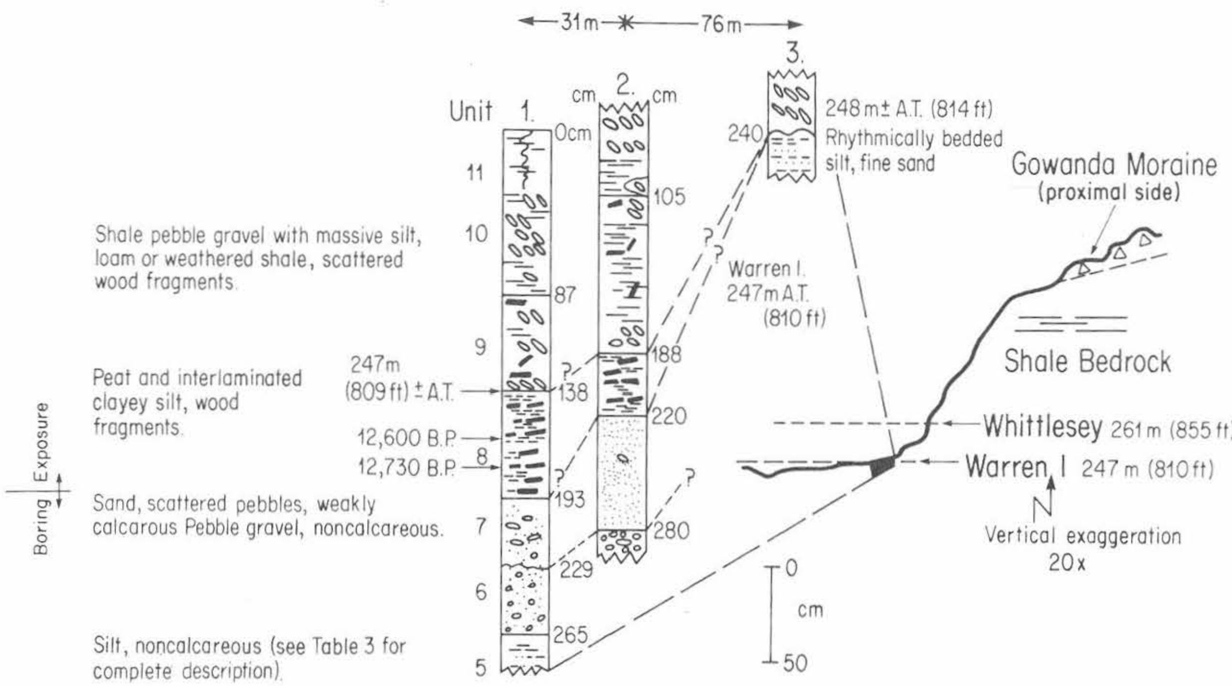

Figure 5. Stratigraphic section at the Winter Gulf Site, North Collins, New York. Units not shown include: 5, 55 cm noncalcareous silt; 6, 244 cm calcareous silt and interbedded sand; 3, 91 cm stony silt and bedded silt; 2, 1250 cm gray, sand-silt-clay till and interbedded stratified silt (Thatcher Till?); and underlying compact, gray-brown, silty sand till. After Calkin and McAndrews (1980).

level on the order of 5 m (16 ft) from the Warren II level corresponding to Lake Wayne of Michigan may have followed as the ice margin backed northward of Buffalo. Fullerton (1980) has suggested that active ice had withdrawn from the Batavia re-entrant, Syracuse channels, and Mohawk Lowland to allow eastward drainage at this time. Assignment of ridges to the Lake Wayne stage is very tenuous at best and field evidence has not corroborated or denied eastward drainage.

Subsequently, water levels rose and drainage returned clearly to the west again with the production of very strong ridges assigned to the Warren III (lowest Warren) stage. Contemporaneously, a readvance of at least 8 km overrode thick ice-contact lacustrine sediments in the Clarence area and deposited thick red basal till possibly culminating in formation of the Alden Moraine just south and west of Buffalo (Fig. 6; Calkin and Miller, 1977; Fullerton, 1980, p. 25). Glacial Lake Warren III persisted through recession from the Alden Moraine position, development of the succeeding Buffalo (= Fort Erie Moraine), Niagara Falls and Batavia moraines. The Batavia Moraine formed after a period of rapid reorganization of the ice front and southwestward readvance to truncate the Niagara Falls Moraine (Leverett, 1902). For the brief period following retreat from the Batavia Moraine, Lake Warren III drained eastward through the Syracuse channels to the Mohawk Valley (Muller, 1977b).

Extensive gravelly kame deltas formed in many areas of Lake Warren, including the distal margins of the Buffalo Moraine in downtown Buffalo and Clarence. Cross bedding, climbing ripples, and similar primary structures in these deposits record the strength and density of depositional currents moving off the ice margin into >60 m (197 ft) of water. The ubiquitous silt and clay blanketing most of the Erie Lowland must reflect the periods of lake ice cover that prevailed through a substantial, colder, part of the glacial lake year in this area.

The Glacial Lake Warren beaches are built out farther from the plateau margin than those of Lake Whittlesey and are best developed on broad deltaic deposits that occur along major stream mouths such as occur near Hamburg, Alden and Crittenden in Erie County (Calkin, 1970). In shallow shelf areas such as Brant and Eden in southwestern Erie County, the deltaic sands were spread out over extensive areas by waves. The Whittlesey and Warren beaches may be somewhat better developed in New York than Ontario (MacLachlan, 1938) and this observation with the orientation of spits and bars, suggests that westerly winds prevailed during strand formation.

Isostatic rebound has caused the Whittlesey and Warren strand lines to rise northeastward through New York at a gradient of about 0.5 m km^{-1} ($\sim$2.5 ft mi^{-1}) (Fig. 7). Approximately 9 m (30 ft) of uplift occurred between Whittlesey and Warren III time at Buffalo near the mouth of the Niagara River (and threshold of Lake Erie). Fifty-two meters (172 ft) of uplift has occurred here since the lowering of Lake Whittlesey (Calkin, 1970).

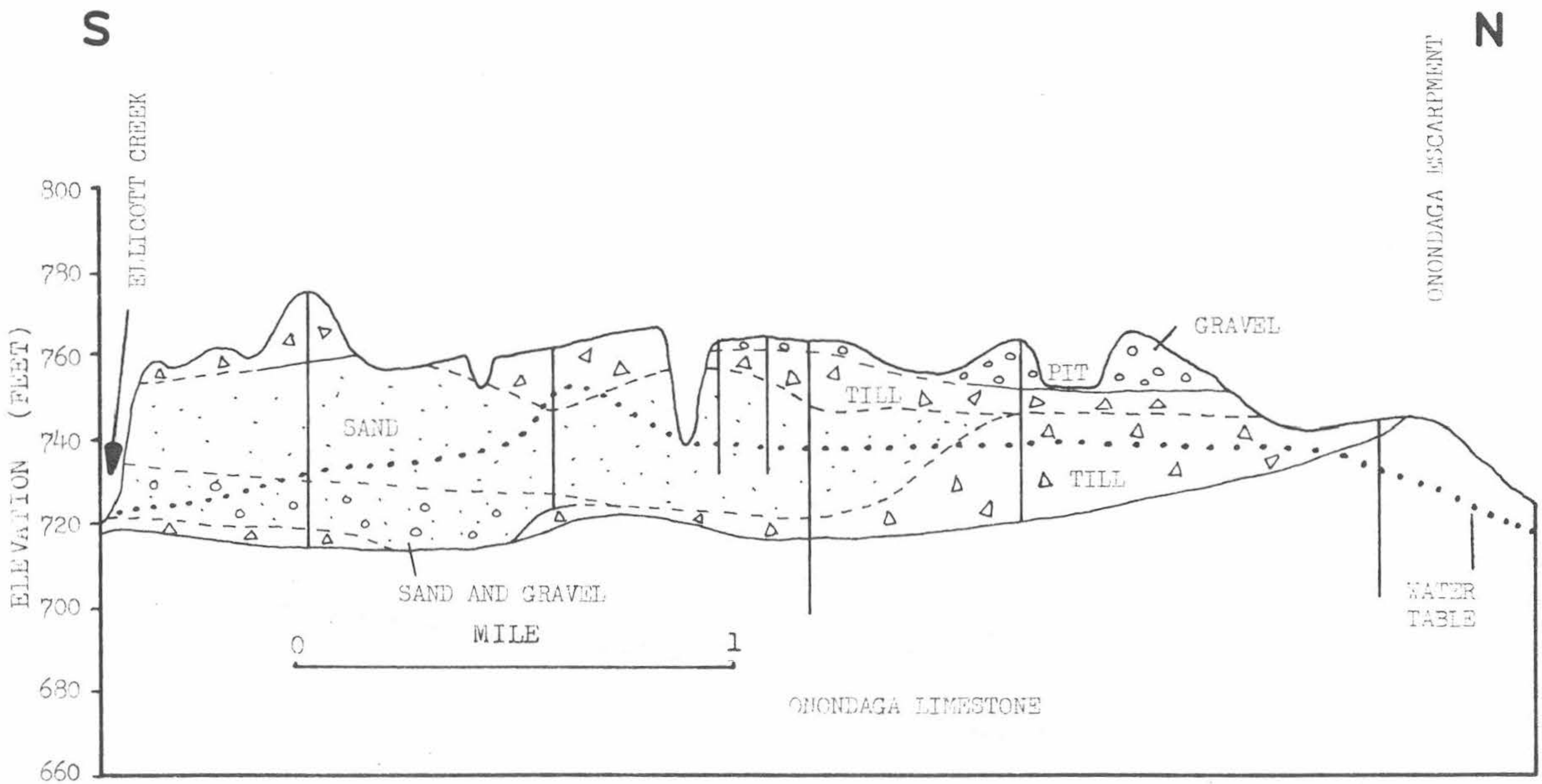

Figure 6. North-south stratigraphic section through the Buffalo Moraine area between the Onondaga Limestone Escarpment (N.Y. Route 5) Clarence, and Ellicott Creek, Town of Lancaster, New York. Anonymous (1982).

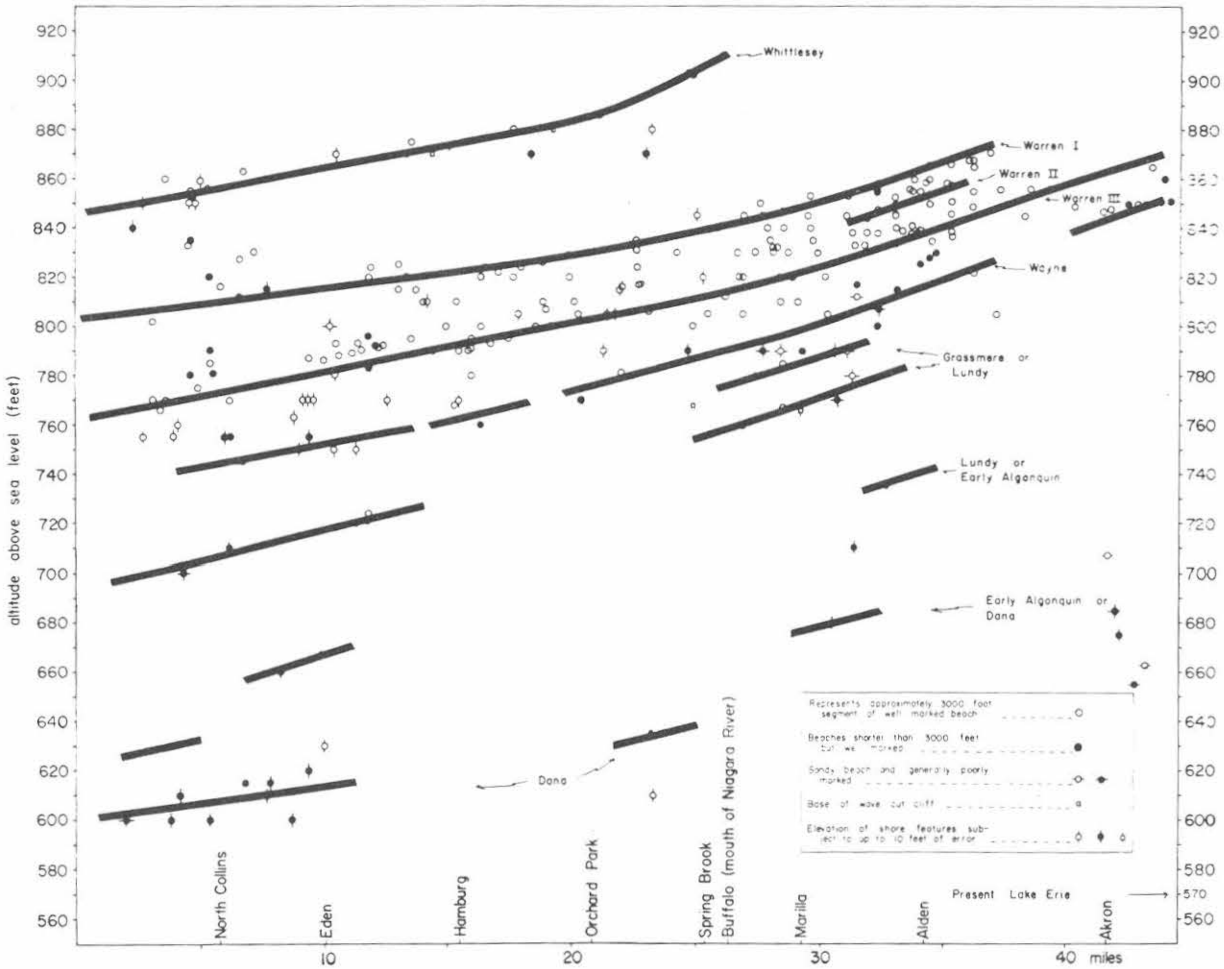

Figure 7. Tilted strand lines of the Glacial Great Lakes, Erie County, N.Y. Elevations from beach crests are projected to a line oriented N 24°E between Cattaraugus Creek at Vessailles and the town of Indian Falls. Heavy lines drawn by hand to suggest water planes have little control below Warren III level. From Calkin (1970, Fig. 4).

The beaches below those of Warren III in the New York portion of the Erie Basin are very discontinuous and display less than 3 m (10 ft) of relief. This is partly due to rapid isostatic uplift, but is also related to the limited beach materials on the clay-covered lake plain where the lakes shoaled and the short duration of each successive lake stand. In order of formation and decreasing elevation, the scattered beach segments have been correlated tentatively with glacial lakes Grassmere, Lundy, Early Algonquin, and Dana (Fig. 2; Hough, 1963, 1966; Calkin, 1970). Retreat from the Batavia re-entrant may have allowed eastward drainage of Lakes Grassmere and Lundy (Fullerton, 1980) but Early Algonquin if once existent in this area, was controlled by outlets to the west (Hough, 1966; Calkin, 1970).

During the post-Warren III lake stages the ice margin retreated at least 30 km northward, with short stands to form the Barre Moraine just above the Niagara Escarpment, and the Albion-Rochester Moraine locally just below it in Niagara County (Fig. 1). Lake Dana, which was confined to the northeastern end of the Erie Basin and southwesternmost portion of the Ontario Basin, drained eastward through the Syracuse channels to the Mohawk and Hudson Valleys following retreat from the Albion-Rochester Moraine (Calkin, 1970). It represented the slowly subsiding waters immediately preceding emergence of the Niagara Escarpment, nearly simultaneous formation of nonglacial, Early Lake Erie (Lewis and others, 1969) and development of Glacial Lake Iroquois in the Ontario Basin, and the initiation of Niagara Falls and Gorge (Calkin and Brett, 1978). A short readvance during initial stages of Glacial Lake Iroquois is marked by the Carelton Moraine near the present south coast of Lake Ontario.

Dating and Climatic Environment

The last glacial retreat and succession of glacial lakes across the lowland must have taken less than 1000 years. The Port Huron advance of Michigan and the rise to Lake Whittlesey level seem to be well dated at about 13,000 yr B.P. although data are not yet locally available to refine this further (Dreimanis and Goldthwait, 1973; Fullerton, 1980). The oldest date for initiation of Early Lake Erie is 12,650 ± 170 yr B.P. (Lewis, 1969) and for Lake Iroquois, 12,660 ± 400 yr B.P.; however, both samples may have been contaminated with recycled carbon and are too old (Calkin and Brett, 1978; Calkin and McAndrews, 1980). Other radiocarbon dates from the Lake Ontario and St. Lawrence areas suggest that Early Lake Erie and Lake Iroquois formed prior to about 12,200 yr B.P. (see Fullerton, 1980).

At the Winter Gulf site south of Buffalo (Figs. 1 and 5), dates of 12,730 ± 220 and 12,610 ± 200 yr B.P. were obtained on wood from a shallow water peat within the lake plain but below the Lake Whittlesey strand level. The peat is in turn separated by 4 to 5 m of lake sediments from an underlying till correlated with the Thatcher Till of the Lake Escarpment glaciation (Calkin and others, 1982). The wood dates are therefore minima for the last glacial retreat from this area, for lowering of Glacial Lake Whittlesey, and for northward retreat of the ice margin from the Hamburg or Marilla moraines in western New York (Calkin and McAndrews, 1980). The ice margin could have been as close as 21 km but was likely near the present coast of Lake Ontario, 80 km to the north when peat deposition began at Winter Gulf.

The pollen profile from both Winter Gulf and Nichols Brooks are dominated by spruce and other pollen which suggest that there was little warming at this time; however, an ecologically unbalanced biota may have occurred. The coleoptera (beetle) assemblage recovered from the peat at Winter Gulf (Schwert and Morgan, 1980) indicates that temperatures of deposition were considerably warmer than those suggested by the pollen. If such warming did occur, it records a rather sudden change from conditions of permafrost that may have existed in southwestern Ontario and nearby New York until the early phase of the Port Huron advance (Calkin and McAndrews, 1980, p. 305; Schwert and Morgan, 1980).

REFERENCES

Barnett, P. J., 1979, Glacial Lake Whittlesey: the probable ice frontal position in the eastern end of the Erie basin: Canadian Journal of Earth Sciences, v. 16, p. 568-574.

Bertie, A. A., 1975, Paleobotany of Wisconsinan Interstadials, eastern Great Lakes region, North America: Quaternary Research, v. 5, p. 591-619.

Birkeland, P. W., 1974, Pedology, weathering and geomorphological research: New York, Oxford Univ. Press, 285 p.

Calkin, P. E., 1970, Strand lines and chronology of the glacial Great Lakes in northwestern New York: Ohio Journal of Science, v. 70, p. 78-96.

Calkin, P. E. and Brett, C. E., 1978, Ancestral Niagara River drainage: Stratigraphic and paleontologic setting: Geological Society of America Bulletin, v. 89, p. 1140-1154.

Calkin, P. E. and McAndrews, J. H., 1980, Geology and paleontology of two Late Wisconsin sites in western New York: Geological Society of America Bulletin, Part I, v. 91, p. 295-306.

Calkin, P. E. and Miller, K. E., 1977, The Quaternary environment and man in western New York: Annals of the New York Academy of Science, v. 288, p. 297-315.

Calkin, P. E. and Muller, E. H., 1980, Geologic setting and glacial overview of the upper Cattaraugus Basin, southwestern New York, <u>in</u> LaFleur, R. G., Late Wisconsin stratigraphy of the upper Cattaraugus Basin: Northeast Friends of the Pleistocene, guidebook for 43rd annual reunion, Springville, N.Y. (available from R. G. LaFleur, Dept. of Geology, Rensselaer Polytechnic Inst., Troy, N.Y. 12181).

Calkin, P. E. and Wilkinson, T., 1982, Glacial and engineering geology aspects of the Niagara Falls and Gorge <u>in</u> Buehler, E. and Calkin, P., eds., Geology of the Northern Appalachian Basin, western New York, Guidebook for 54th annual meeting, New York State Geological Association, Amherst, N.Y.

Calkin, P. E., Hodge, D. S., Champion, D. E., Oaksford, E. T., and Palmer, E. C., 1974, Gravity delineation of the preglacial Cazenovia River Valley, Western New York State, U.S.A.: Zeitschrift für Geomorphologie N.F. Band 18, Heft 3, p. 247-259.

Calkin, P. E., Muller, E. H. and Barnes, J. H., 1982, The Gowanda Hospital Interstadial site, New York: American Journal of Sciences, in press.

Chapman, W. F. and Craft, J. L., 1976, Glacial aspects of the Oil City area, in Ward, A. N., Chapman, W. F., Lukert, M. T., and Craft, J. L., Bedrock and Glacial Geology of Northwestern Pennsylvania in Crawford, Forest and Venango Counties: 41st Annual Conference of Pennsylvania Geologists, Harrisburg, PA, Bureau of Topographic and Geologic Survey, p. 1-6.

Coates, D. R., Landry, S. O., and Lipe, W. D., 1971, Mastodon bone age and geomorphic relations in the Susquehanna Valley: Geological Society of America Bulletin, v. 82, p. 2005-2010.

Cole, W. S., 1941, Nomenclature and correlation of Appalachian erosion surfaces: Journal of Geology, v. 49, p. 129-148.

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

Donahue, J. J., 1972, Drainage intensity in western New York: Annals of the Association of American Geographers, v. 62(1), p. 23-36.

Dreimanis, A., and Goldthwait, R. P., 1973, Wisconsin glaciation in the Huron, Erie, and Ontario lobes: Geological Society of America Memoir 136, p. 71-105.

Dreimanis, A., and Karrow, P. F., 1972, Glacial history of the Great Lakes - St. Lawrence region, the classification of the Wisconsin(an) stage, and its correlatives, 24th International Geological Congress, Section 12, p. 5-15.

Dreimanis, A., and Raukas, A., 1975, Did Middle Wisconsin, Middle Weichselian, and their equivalents represent an interglacial of an interstadial complex in the northern hemisphere? in Quaternary Studies, R. P. Suggate and M. M. Cresswell (eds.), Royal Society New Zealand, Bull. 13, p. 109-120.

Ellis, Lynn Doyle, 1980, Geophysical reconstruction of the Preglacial Allegheny River Valley, western New York: (M.A. Thesis): State University of New York at Buffalo, 83 p.

Fairchild, H. L., 1932, New York Physiography and glaciology west of the Genesee Valley: Rochester Academy of Science Proceedings, v. 7, p. 97-136.

Feenstra, B. H., 1981, Quaternary geology and industrial minerals of the Niagara-Welland area, southern Ontario: Ontario Geological Survey OFR 5361, 260 p. Appendices A-L, 5 tables, 22 figures, 21 photographs, 6 maps, and 4 charts.

Fullerton, D. S., 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., 2 correlation charts.

Gadd, N., 1981, Anorthosite erratics of probable Laurentian origin in the vicinity of Buffalo, New York: Scientific and Technical Notes in

Current Research, Part C; Geological Survey of Canada, Paper 81-1C, p. 63.
Hobson, G. D., and Terasmae, J., 1969, Pleistocene geology of the buried St. Davids gorge, Niagara Falls, Ontario: geophysical and palynological studies: Geological Survey Canada, Paper 68-67, 16 p.
Hodge, D. S., unpublished manuscript, A gravity study of the preglacial Buttermilk River valley near Springville, New York.
Hollands, G. G., 1973, History of deglaciation of southern Erie County, western New York: Geological Society of America Abstracts with Programs, v. 5(2), p. 178.
Hough, J. L., 1963, The prehistoric Great Lakes of North America: American Scientist, v. 51, p. 84-109.
_________, 1966, Correlation of glacial lake stages in the Huron-Erie and Michigan basins: Journal of Geology, v. 74, p. 62-77.
LaFleur, R. G., 1979, Glacial geology and stratigraphy of western New York Nuclear Service Center and vicinity, Cattaraugus and Erie counties, New York: U.S. Geological Survey Open-File Report 79-789, 17 p.
_________, 1980, Late Wisconsin stratigraphy of the upper Cattaraugus Basin: Northeast Friends of the Pleistocene, guidebook for 43rd annual reunion, Springville, N.Y. (available from R. G. LaFleur, Dept. of Geology, Rensselaer Polytechnic Institute, Troy, N.Y. 12181).
Leverett, F., 1902, Glacial formations and drainage features of Erie and Ohio basins: U.S. Geological Survey Monograph 41.
Lewis, C. F. M., 1969, Late Quaternary history of lake levels in the Huron and Erie basins, in Great Lakes Research Conference, 12th Ann Arbor, Michigan, 1969, Proceedings: International Association of Great Lakes Research, p. 250-270.
MacClintock, P., and Apfel, E. T., 1944, Correlation of the drifts of the Salamanca Re-entrant, New York: Geological Society America Bulletin, v. 55, p. 1143-1164.
MacLachlan, D. C., 1939, Warren Shore in Ontario and the Thumb of Michigan and its deformation: Ph.D. thesis, University of Michigan, Ann Arbor, Michigan, 89 p.
Morgan, A. V., and Morgan, A., 1977, The age and distribution of fossil ice-wedge polygon networks in southwestern Ontario, Canada: International Union for Quaternary Research Congress, 10th, Birmingham, England, Abstracts, p. 308.
Morner, N-A., 1973, The Erie interstade, in Black, R. F., Goldthwait, R. P., and Willman, H. G., eds., The Wisconsinan State: Geological Society of America Memoir 136, p. 107-134.
Muller, E. H., 1963, Geology of Chautauqua County New York, part II Pleistocene geology: New York State Museum Bulletin 392, 60 p.
_________, 1964, Quaternary section at Otto, New York: American Journal of Science, v. 262, p. 461-478.
_________, 1975, Physiography and Pleistocene geology, in Geology of Cattaraugus County, New York by I. H. Tesmer, Buffalo Society of Natural Sciences Bulletin 27, p. 10-20.
_________, 1977a, Quaternary geology of New York, Niagara Sheet: New York State Museum and Science Service, Map and Chart Ser. No. 28, scale 1:250,000.

__________, 1977b, Late glacial and early postglacial environments in western New York: Annals of the New York Academy of Science, v. 288, p. 223-233.

Muller, E. H., Young, R. G., Rhodes, D. D., Willette, Paul, and Wilson, Michael, 1975, Surficial geology of the Genesee Valley, N.Y.: Ms. report, New York Geological Survey.

Owens, D. W., Daniels, R. B., and Brauen, G. B., 1977, Lacustrine sediments in the Allegheny Plateau of Erie County, New York: Their characteristics of distribution and land use problems: Journal of Soil and Water Conservation, v. 32(2), p. 93-97.

Philbrick, S. S., 1976, Kinzua Dam and the glacial foreland, in Coates, D. R., ed., Geomorphology and Engineering: Stroudsburg, Pennsylvania, Dowden, Hutchinson and Ross, Inc., p. 175-198.

Pryor, M., 1975, The glacial history of the Langford, NY 7½' Quadrangle and southern half of the Hamburg 7½' Quadrangle (M.A. Thesis): State University of New York at Buffalo, New York, 58 p.

Schooler, E. E., 1974, Pleistocene beach ridges of northeastern Pennsylvania: Pennsylvania Geological Survey General Geology Report 64, 38 p.

Schwert, D. P., and Morgan, A. V., 1980, Paleoenvironmental implications of a Late Glacial insect assemblage from northwestern New York: Quaternary Research, v. 13, p. 93-110.

Taylor, F. B., 1939, Correlatives of the Port Huron morainic system of Michigan in Ontario and western New York: American Journal of Science, v. 237, p. 375-388.

Wall, R. E., 1968, A sub-bottom reflection survey in the central basin of Lake Erie: Geological Society of America Bulletin, v. 79, p. 91-106.

White, G. W., Totten, S. M., and Gross, D. L., 1969, Pleistocene stratigraphy of northwestern Pennsylvania: Pennsylvania Geological Survey, 4th Series, General Geology Report G 55, 88 p.

ROAD LOG
GLACIAL GEOLOGY OF THE ERIE LOWLAND AND ADJOINING ALLEGHENY PLATEAU, WESTERN NEW YORK

(Route and location of stops are shown in Figure 1)

CUMULATIVE MILEAGE	MILES FROM LAST POINT	ROUTE AND STOP DESCRIPTION
0.0	0.0	From Buffalo Marriott Inn turn left (north) onto Millersport Highway (Rt. 263 N).
0.2	0.2	Turn right, proceed east on Maple Rd.
2.9	0.7	Cross Hopkins Rd. with slight rise of Niagara Falls morainal ridge on right, Lake Tonawanda plain to left.

6.2	3.3	Turn right (south) onto Harris Hill Rd. with subdued hillocks of Niagara Falls Moraine partly mantled by Lake Warren silts. Rise up Onondaga Limestone Escarpment.
7.8	1.6	Turn left and proceed east on Rt. 5 (Main St.). Sandy soils on Escarpment edge here result from winnowing of older sediments by Lake Dana waters.
12.1	4.3	Descend Escarpment into river embayment at Clarence Village. Recent U.S. Geological Survey borings suggest that a large buried (drift-filled) valley connects the embayment southward with the present valley of Ellicott Creek near Stop 1.
12.5	0.4	Turn right onto Ransom Rd. Rise south back up Onondaga Escarpment onto gravel plain related to Buffalo Moraine and deposited in Lake Warren III. Beaches of lower stage--Lake Grassmere occur along Escarpment crest.
		Cross over N.Y.S. Thruway into Town of Lancaster.
15.0	2.5	Turn right (west) at traffic light onto Genesee St. (Rt. 33).
16.0	1.0	Turn left off Genesee St. into lot just east of Shisler Rd. intersection.

STOP 1. PINE HILL GRAVEL PIT.

Pit is cut into a portion of the Buffalo Moraine and is just on north margin of present northwest-flowing Ellicott Creek. Borings made for the study of the gravel aquifer (Fig. 6) in this area show two till sheets with sand and gravel between. This and several adjoining excavations expose the thick sand and gravel units deposited in at least 30 m (100 ft) of Lake Warren III or earlier stage. Thin red lake clay partings separate thick rippled sand units (varves?). The overlying till and sand/gravel unit shows evidence of flow and deformation (often irregularly interfingering). The till, laid down by thin, sometimes bouyant ice margin, can be traced at least to the Alden Moraine ∿5 mi to the south. Fabrics show moderate NE-SW maxima.

Return eastward on Genesee (Rt. 33E) through traffic light, through Millgrove to Walden Ave.

20.5	4.5	Turn left onto Walden and then immediately right (south) off Walden bending again left along crest of subdued sandy beach or off-shore bar of Lake Warren III.
20.9	0.4	Cross R.R. tracks on beach crest.
21.6	0.7	Bend right on Peters Corners Rd. onto strong Warren III beach ridge. This strand can be traced intermittently to Syracuse and south and west through Cleveland into Michigan.
22.1	0.5	Pit on right excavated in beach ridge. Cross several beach ridges obliquely.
22.6	0.5	Cross R.R. bed cut in Alden Moraine at left (source of beach material) and turn right onto North St. following a Warren III beach (moraine on left).
23.5	0.9	Bear left across Ellicott Creek (flows through U.B. campus) onto Sandridge Rd. and continue south.
24.4	0.9	Cross highest beach ridge of several oblique to Sandridge Rd.
25.2	0.8	Turn right (west) at W. Alden onto Broadway (Rt. 20) and cross several ridges-spits of Warren III. This is the area where Warren III beaches split off northward and Warren I and II? terminate south of Alden Moraine.
25.7	0.5	Turn left onto Four Rod Rd., still crossing Warren ridges.
26.3	0.6	Descend into floodplain and cross Cayuga Creek.
27.0	0.7	Rise across washed till (strand of Lake Warren I - highest Warren) at white farmhouse (∿860 ft [262 m]) and proceed south across Marilla Moraine. Moraine appears unaltered by Lake Whittlesey waters and hence formed before or soon after draining of Whittlesey to Warren I level.
28.2	1.2	Cross Clinton St. going south, still on Marille Moraine.
29.3	1.1	Turn left onto Bullis Rd. and stop along road near corner.

STOP 2. DRAINAGEWAY MARILLA-HAMBURG MORAINES.

View small esker and associated kames to northeast. To west of intersection, Bullis Rd. crosses delta surface formed in Lake Whittlesey and subsequently Lake Warren by water draining along ice margin here.

		Turn around and return to Four Rod Rd. south.
29.5	0.2	Leave Bullis on Four Rod Rd. south and cross Hamburg Moraine.
30.9	1.4	Not good till cut at far left along Little Buffalo Creek.
31.1	0.2	Moulin kame hillock on right behind farm consists of till and poorly sorted gravel. A few similar forms occur just to east out of sight.
31.6	0.5	Turn right onto Parker Rd., follow west to stop sign (in E-W-oriented meltwater channel.
32.5	0.9	Turn left (south) onto Two Rod Rd. (Rt. 358) crossing meltwater channel.
33.0	0.5	Turn right at riding stable onto Jamison Rd.; cross Buffalo Creek--its post-glacial position?
35.7	2.7	Turn left (south) at light onto Girdle Rd. Many gravel hillocks of moraine have been removed here.
36.3	0.6	Cross Aurora Expressway (Rt. 400); note deep cut in moraine.
37.1	0.8	Deep kettle hole and lake on left; hummocky ice-contact drift at distal side of Hamburg Moraine.
37.8	0.7	Turn right onto East Aurora-Porterville Rd. and immediately right again at bend onto Pine St. to East Aurora Waterworks. This is within partly buried valley of Preglacial Cazenovia River which trends northward through the Hamburg Moraine. Valley fill is major water source and buried valley a collector/ conduit of groundwater.
38.7	0.9	Leave Waterworks at stop sign and proceed south on Pine St.

39.1	0.4	Cross Main St., East Aurora Village and Rts. 20A and 78. Proceed straight south on Olean St. (Rt. 16) (continuation of Pine). Note postglacial Cazenovia Creek has been glacially deflected to westward path.
40.9	1.8	Bear right, follow Rts. 16 and 400S. Note glaciated U-shaped valley cross-section modified by alluvial fans at margins.
43.1	2.2	Turn right at South Wales onto Emery Rd. and proceed to Emery Park.

STOP 3. EMERY PARK (Lunch Stop)

The Gowanda Moraine crosses the valley at this point. The park is on the west wall of the partly buried valley (∿60-100 m of drift till) now occupied by East Branch Cazenovia Creek. Ice flow was approximately parallel to this and adjoining valleys. High level deltas graded to proglacial "finger lakes" line the east valley wall in this general area.

		Leave Park and pick up mileage at Rt. 16 intersection. Turn right southward.
48.7	5.6	Cross East Branch Cazenovia Creek. Creek is on bedrock at right, deepest part of valley is to left (east) of bridge. Pass through Village of Holland and rise southward onto proximal side of Lake Escarpment Moraine (bedrock actually fills slightly southward).
54.0	5.3	Turn right onto Hand Rd. at crest of Lake Escarpment Moraine.
54.3	0.3	Turn around at Chaffee solid waste disposal site (landfill). Although tills appear quite thick and dense here, the Chaffee Outwash Plain heads at north margin of the current landfill boundary and critically close to leachate drainage.
54.7	0.4	Right (south) onto Rt. 16. Note meltwater channels on right leading to head of outwash plain within few tenths of a mile.
56.2	1.5	Cross Grove St., Chaffee, on outwash plain. Note irregularly south-sloping surface, probably effected by differential settling. A nearby gas well reached bedrock at about 188 m (615 ft) depth (see Calkin and others, 1974).

57.7	1.5	Nichols Brook site (Calkin and McAndrews, 1980) on left.
58.0	0.3	At intersection with Rt. 39, turn left onto East Schutt St. (becomes Howe Rd.).
58.9	0.9	Cross R.R. track and pass out of Preglacial Cazenovia Valley toward Arcade.
59.9	1.0	Park at right (south side) of road just east of red farmhouse.

STOP 4. ARCADE SECTION.

The stratigraphy at this active cut-bank of Cattaraugus Creek is shown in Figure 4. The locality is south of the Lake Escarpment Moraine. At least three till units are exposed, separated by glacial lake deposits. The upper till is thin and has textural properties strongly influenced by underlying lacustrine deposits and appears to indicate deposition from thin ice. The lower tills are thicker and generally more homogeneous in their properties although the lowest unit carries clasts of red till and clay. The tills are tentatively correlated with Hiram, Lavery, and Kent drifts on the basis of sequence.

		Return westward along Howe and East Schutt Streets.
61.8	1.9	Turn left (south) onto Rt. 16S.
62.1	0.3	Turn left obliquely off Rt. 16 onto dirt road (before descending onto floodplain of Cattaraugus Creek) leading to gravel pit.

HESITATION STOP - GERNATT GRAVEL PIT

Good exposure (when working) of Chaffee Outwash at Cattaraugus Creek where it overlies till (generally not exposed but just above creek level). Near-horizontally bedded and very well sorted gravel overlies steeply inclined (foreset) units which on one visit appeared to be associated with till units.

		Pick up mileage at Rt. 16.
		Proceed north onto Rt. 16.
62.4	0.3	Turn left onto Rt. 39W.
62.8	0.4	Cross bedrock-cored ridge dividing buried valley into two channels. Deepest channel is on west side and connects valley to south of Cattaraugus Creek with present valley of East

		Branch Cazenovia Creek Valley (not with Buffalo Creek [Calkin and others, 1974]).
63.7	0.9	Bear left on 39W toward Springville.
65.9	2.2	Descend from outwash surface into Cattaraugus Creek Valley. Bluemont Ski area to south across creek.
66.6	0.7	Note slumped till of Lavery Till on right, Lord Hill Section of LaFleur (1979, 1980) on left at Creek. Strong fluvial dissection exposes till and lake sediments in the valley area.
70.7	4.1	Rise out of postglacial valley onto outwash tied to Springville Outwash Plain. Lake Escarpment morainal ridges are to north.
71.8	1.1	Cross Rt. 240.
72.9	1.1	At hospital, descend into Village of Springville occupying spillway that drained proglacial lake in North Branch Eighteenmile Creek and West Branch Cazenovia Creek. This is center of Preglacial Buttermilk Creek heading several miles to south.
73.6	0.7	Proceed straight (west) on Rt. 39. (The most scenic route would trend left via Waverly St. and Zoar-Gowanda Rd. but roads are narrow and steep, and bridge weight limits prohibit bus traverse.)
74.5	0.9	Cross Rt. 219 and leave outwash plain crossing onto distal ridge of Lake Escarpment Moraine.
78.8	4.3	Cross onto outwash plain (still on Rt. 39) at head of South Branch Eighteenmile Creek. Formed by meltwater of Lake Escarpment Moraine shed southward into buried Preglacial Connoisarauley River Valley.
80.0	1.2	Rise off outwash onto Lake Escarpment Moraine as it trends north-south.
80.7	0.7	Bear left continuing on Rt. 39.
85.2	4.5	Cross Rt. 75 at Collins Center and onto gravel valley till (underlain by lake clay and till respectively).

88.6	3.4	Cross Gowanda Moraine. Stratigraphic sections suggest moraine formed as ice advanced into proglacial lake.
90.1	1.5	Turn left (south) onto Rt. 62 within Clear Creek Valley (part of Preglacial Allegheny Valley) and park near corner. Reach exposure downstream from highway bridge 0.3 mi south.

STOP 5. GOWANDA HOSPITAL INTERSTADIAL SITE.

This site exposes three till units, a buried paleosol and overlying organic horizon. It is briefly described in the text and Figures 3a, b, and c. The right bank section is rarely exposed but the paleosol and wood horizons on the left bank are often clear after minor work. One of the most important aspects of the site is the Gowanda Paleosol, a buried, truncated (of its A horizon) soil whose substantial development and stratigraphic positioning appears to argue for a long mid-Wisconsin nonglacial interval prior to about 50,000 yr BP (Calkin and others, 1982).

One of the many problems of the stratigraphy is the age and correlation of the brown till unit. The till material appears to be derived locally by glacial erosion of the underlying, weathered red "Collins" till and therefore it is difficult to correlate regionally with other till units. Although it displays mudflow-like contacts with the channel gravel, it also shows good glaciotectonic structures including wood sheared from underlying deposits. The age of the wood suggests a mid-Wisconsin ice advance; however, there is some question whether the ice sheet reached past this area to Titusville, Pennsylvania, in Middle Wisconsin interval as suggested by current correlations (Figs. 2 and 3b).

		Proceed north on Rt. 62 from intersection with Rt. 39.
90.5	0.4	Turn left (west) onto Richardson Rd. rising onto Fairchild's (1932) Asylum (Gowanda State Hospital) Terrace graded to a local proglacial lake in the Cattaraugus Creek (Preglacial Allegheny) embayment of the Erie Basin. This surface is an extension of top gravel unit (8) at Gowanda Hospital site.
91.1	0.6	Turn right (north) onto Taylor Hollow Rd. View at left of Fourmile Level, a delta surface (on Cattaraugus Indian Reservation) formed in Lake Whittlesey and later Lake Warren.
91.4	0.3	Gravel pit at right displays large foreset bedding units in thickened section of Asylum Terrace seen at the Gowanda Hospital site (Fig. 3a, unit 8).

93.5	2.1	Bear left at intersection with Rt. 62 and proceed north with Gowanda Moraine parallel to right.
94.1	0.6	Cross Genesee Rd. at Lawton Corners. Rt. 62 follows along zone of weak strand lines of Lake Whittlesey and Lake Warren I. Lowland on left is an old buried tributary valley of Allegheny River.
95.8	1.7	Cross Winter Gulf (unofficial name) and organic site on left (Schwert and Morgan, 1980; Calkin and McAndrews, 1981). The section here is diagramed in Figure 5.
96.6	0.8	Turn left onto Milestrip Rd. (just south of a "Friends" cemetery built on a delta of Lake Whittlesey). Cross gravelly ridges (before low point) intermediate between Whittlesey and Warren (possibly Arkona?). Note ridge-spit extending from west (on right) graded first to Lake Whittlesey and later modified by Lake Warren waters.
97.6	1.0	Turn right onto Mile Block Rd. Spit visible (again) extending eastward is tied to well-developed Whittlesey beach (visible on left) which completely encloses bedrock-based high area here (plateau outlier).
99.1	1.5	Turn left (west) at intersection onto Rt. 249W. Cemetery at intersection spans a Warren ridge.
99.2	0.1	Turn left into gravel pit of Early Sunrise Construction Co.

STOP 6. NORTH COLLINS, WHITTLESEY BEACH EXPOSURE

The Glacial Lake Whittlesey beach with crest at 850 ft (260 m) here is almost totally composed of shale, eroded from the local bedrock (Calkin, 1970, Fig. 2). The good development of the ridge on this narrow-embayment-side of the island in Lake Whittlesey is of interest. Lake Whittlesey extended southwest beyond Toldeo and into the Huron Basin. Several ridges of Lake Warren occur below the Whittlesey ridge; many have been destroyed by years of farming or construction.

Return to Rt. 249E and proceed east (off Whittlesey island) to center of North Collins Village.

100.9	1.7	Turn left (north) at Rt. 62 (intersection at North Collins is on delta deposits of Lake Whittlesey). Rt. 62 follows along Lake Warren beach ridge. Lake Whittlesey beach is visible intermittently on incline to right (east), lower Warren ridges to left with deeper water silts and clays.
104.4	3.5	Whittlesey beach and wave-cut cliff exhumed in old gravel pit at right.
105.7	1.3	Pass main intersection in Village of Eden and exit to N.Y.S. Thruway.
107.4	1.7	Lake Warren beach ridges exposed in gardens on either side of road.
107.9	0.5	Cross South Branch Eighteenmile Creek. This and similar cuts are apparently post-glacial gorges.
109.1	1.2	View to right (northeast) of wave-cut beach and bluff of Lake Whittlesey. Rts. 62 (and 18) unite with Rt. 75N.
110.5	1.4	Cross North Branch Eighteenmile Creek. Cemetery on right and road itself still on Lake Warren beach.
111.4	0.9	Turn left at intersection in Village of Hamburg and follow Rt. 75N to N.Y.S. Thruway.
113.5	2.1	Turn onto N.Y.S. Thruway and keep left after toll barrier north to Buffalo.
120.4	6.9	Toll barrier at Lackawanna.
130.4	10.0	Exit right (#50) to Youngmann Hwy. (I-290) toward Niagara Falls.
131.4	1.0	Pass under Rt. 5 and through Onondaga Escarpment. Note south dip of strata. This was formerly a prize fossil collecting quarry.
133.4	2.0	Exit right for Millersport Hwy. (N.Y. 263N).
134.2	0.8	Turn into Buffalo Marriott Inn.