GLACIAL MORPHOLOGY OF UPPER SUSQUEHANNA DRAINAGE

P. Jay Fleisher
SUNY, College at Oneonta

INTRODUCTION

The geomorphology of east-central New York State reveals the cumulative erosional effects of multiple glacial events, but the deposits of only the last ice sheet are known. Evidence for pre-Wisconsin glaciation has long been recognized along the glacial limit in Pennsylvania and from isolated and widely spaced localities in New York. However, the glacial chronology of the eastern Appalachian Plateau is confined to subdivisions of the Wisconsin Glaciation as displayed in the landforms and stratigraphy. Those factors that influenced glacier pulses, flow regime, and ice-marginal activity were widely variable across New York State, resulting in problems of correlation and chronology. In spite of this, a comprehensive picture has been developed through the combined efforts of many contributors who have concentrated on specific areas, drainages, and problems.

Within the area of the upper Susquehanna drainage are the deposits of mid-Wisconsin to late Wisconsin deglaciation. A characteristic assemblage of depositional landforms constitutes the valley floor morphology and represents a particular environment of deglacial processes. The valley walls and divides are, for the most part, examples of the combined effects of erosional and depositional conditions of a different glacial environment. The emphasis of this report will be to consider the glacier environments of deposition as represented by the landforms and their stratigraphy.

The area under consideration lies within Otsego County, along the upper reaches of the Susquehanna River from Wells Bridge to Otsego Lake. This discussion will include areas represented in part by the Unadilla, Otego, Franklin, Oneonta, Mt. Vision, Hartwick, West Davenport, Schenevus, Milford, Cooperstown, Westford, and Cherry Valley quadrangles, as illustrated in figure 1. Beginning in Wells Bridge and moving upstream along the Susquehanna the main tributaries are Otego Creek from the north at West Oneonta, Charlotte Creek from the east at Emmons (east of Oneonta), Schenevus Creek from the northeast at Colliersville (also east of Oneonta), Cherry Valley Creek from the northeast at Milford, and Oaks Creek from the northwest near Cooperstown.

Various aspects of the Quaternary geology within this area and adjacent parts of the Appalachian Plateau have been investigated and reported by several past workers. In addition to the general overview treatment given by Fairchild (1925) and Rich (1935), Coates (1974) and Coates and Kirkland (1974) considered the regional significance of main drainage ways and the general distribution of ice-marginal deposits. Krall's work (1972) included the drumlins near Richfield Springs and the occurrence and correlation of various moraines through this area. The work of Whipple (1969) also contributed to an understanding of the Quaternary geology north of Cooperstown. The Chenango drainage to the west has been studied by Cadwell (1972), who not only suggested a conceptual model for stages of deglacial events, but also provided an absolute age that has helped to establish a correlative chronology with other parts of the state. To the east is the Schoharie drainage, in which Le Fleur (1969) considered the unique aspects of Wisconsin glacial pulses into a north flowing river system and the northern Catskill slopes. Additional details of Catskill glacial history are contained in the work by Kirkland (1973) in the West Branch of the Delaware River of Delaware County to the south.

The purpose of this report is to present a general overview of the geomorphic development of the upper Susquehanna area, with special attention given to the glacial landforms and deglacial events. Hopefully, this will serve to fill the central gap between adjacent areas.

REGIONAL SETTING

This portion of the Appalachian Plateau is characterized by deeply dissected middle to upper Devonian clastic stratigraphy. Bedrock strata include interfingered and discontinuous beds and lenses of sandstone, siltstone, shale and sparse conglomerates of the Hamilton and Genesee Groups. The regional dip is to the south-southwest at angles typically less than 10°. In general, the bedrock of the region is well expressed by the topography. Some divides and broad, arcuate questas are capped by more massive parts of the stratigraphy and the subtle structural configuration can be seen on a regional scale.

The topography shows the compound influence of a fluvioglacial origin with the Susquehanna River as the main trunk stream. The present drainage was glacially modified from an elongate and incised dendritic pattern to an ice-scoured system of enlarged valley troughs and through valleys, with associated berms, umlaufbergs, and truncated spurs. Ice-scoured bedrock and thin lodgement till characterizes the uplands, however isolated occurrences of stratified drift are known to exist also. Large scale plucking of competent rock types has produced scattered basins in which upland lakes and bogs have formed.

Local relief typically reaches 600 to 700 feet. However, if one considers the drift that chokes the valley floors to thicknesses that generally range between 200 to 300 feet (Randall, 1972, Gieschen, 1974), the erosional relief is seen to be considerably greater. The drift is almost entirely sorted, even in moraines, and consists of glaciofluvial and glaciolacustrine gravel, sand, silt and clay.

Two large lakes (Canadarago and Otsego) dominate the headwater valleys of the Susquehanna River. Both are vestiges of ice-contact lakes that occupied moraine dammed basins. Otsego Lake, the larger of the two, currently occupies a considerably deeper basin with a maximum depth of 166 feet compared with 44 feet in Canadarago (Weir and Harman, 1974). Sometime following deglaciation the spillways of both lakes breached their impounding moraines and the lakes receded to approximately their present positions. A similar geomorphic situation can be interpreted for other parts of the drainage that are completely free of lakes today.

DRAINAGE DEVELOPMENT

Preglacial Geomorphology

The Susquehanna River and others of similar antiquity in the northeast have been the subject of geomorphic conjecture through decades of published literature. The age and evolutionary development of the Susquehanna along its full course through the Valley and Ridge, Piedmont and Coastal Plain Provinces remains a classic conundrum. However, here near its present head on the Appalachian Plateau, the situation seems somewhat less complex.

Although pre-tertiary paleogeomorphology is difficult to decipher and remains speculative at best, the tectonic history of central New York provides a framework upon which a geomorphic history can be pieced together. The earliest possible origin for the upper Susquehanna drainage dates back to the last marine emergence of this region. With late Paleozoic erosional remnants capping undeformed Devonian strata of western New York and adjacent Pennsylvania, it appears as though regional erosion and drainage development did not begin prior to late Permian or early Triassic time. It would have been at about this interval that the Hudson Valley began to take shape as the ancestral Hudson River flowed south along the trace of the Taconic thrusts and Acadian age fold structures. As this drainage and its tributaries developed, the Mohawk Valley was carved in similar less resistant lower Paleozoic strata. It is suggested that subsequent headward erosion eventually captured the original Susquehanna headwaters from the Adirondack flanks and diverted them into the Hudson Valley. As a result, the Susquehanna River was beheaded and its new divide shifted southward in a series of hanging valleys. Further development of the Mohawk and its tributaries established the Schoharie drainage in competition with the easternmost Susquehanna. A schematic representation of this general development is shown in figure 2.

Although repeated glacial erosion has modified this original drainage system, some valleys oriented perpendicular to the general ice flow remained relatively unaltered and still retain vestiges of their pre-glacial character. This is the case along that part of Ouleout Creek which flows northwesterly through East Sidney before joining the Susquehanna. Here, the valley morphology consists of well preserved small scale engrown meanders that are modified only by a shallow valley train. Even along many of the main drainageways subparallel or parallel to ice flow, the glacially modified sweeping curvatures of large meander remnants can still be recognized as part of the pre-glacial morphology. Several good examples of this can be seen along the Susquehanna near Otego and again at Milford Center, as well as along Schenevus Creek. When viewed in detail, the large scale streamlining effects and over steepening of slopes resulting from glacial erosion can be readily seen, however the unmistakable meander morphology is well preserved.

Figure 2

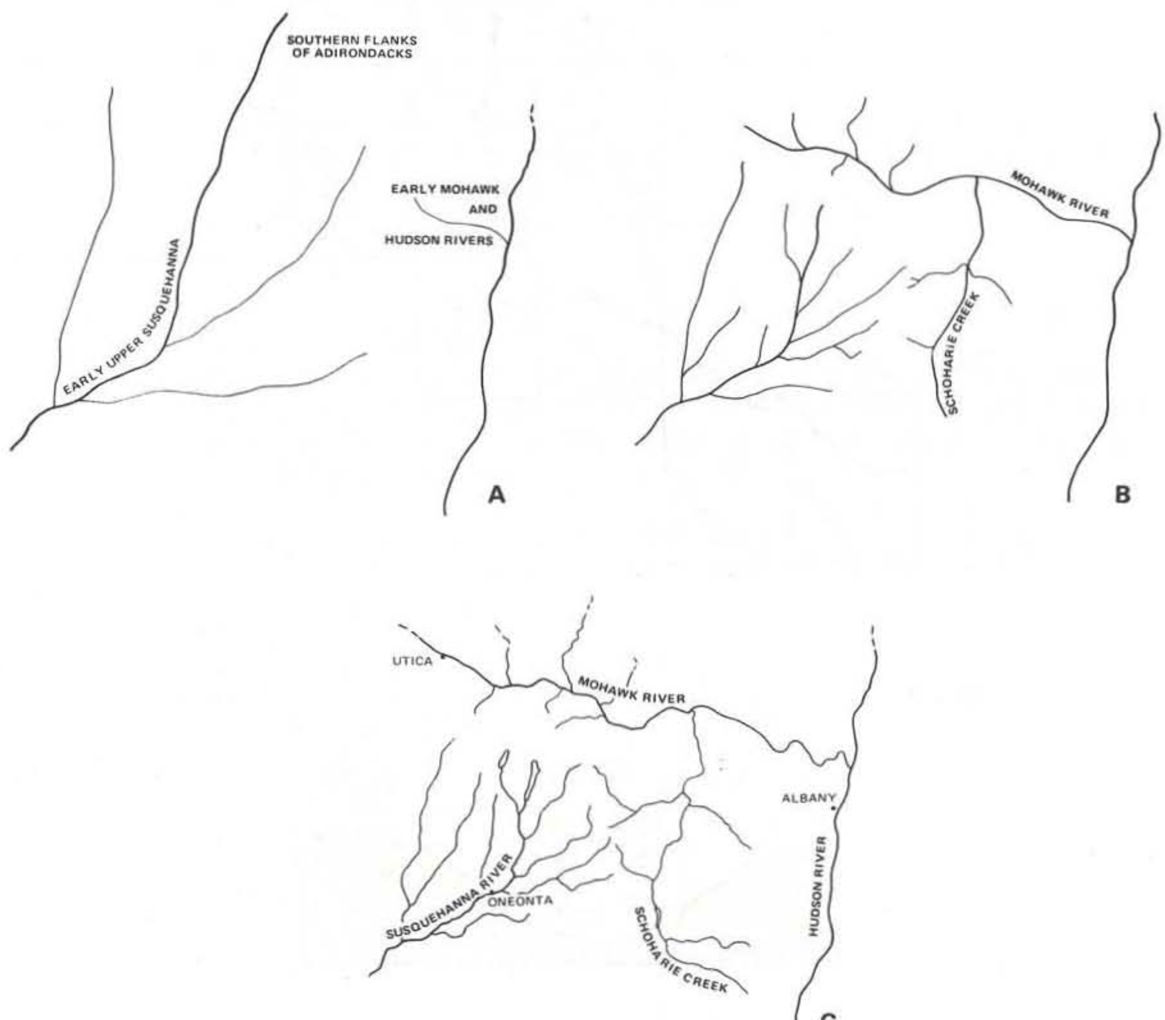

SOUTHERN FLANKS
OF ADIRONDACKS
EARLY UPPER SUSQUEHANNA
EARLY MOHAWK
AND
HUDSON RIVERS
A
MOHAWK RIVER
SCHOHARIE CREEK
B
UTICA
MOHAWK RIVER
ALBANY
HUDSON RIVER
SUSQUEHANNA RIVER
ONEONTA
SCHOHARIE CREEK
C

Figure 4

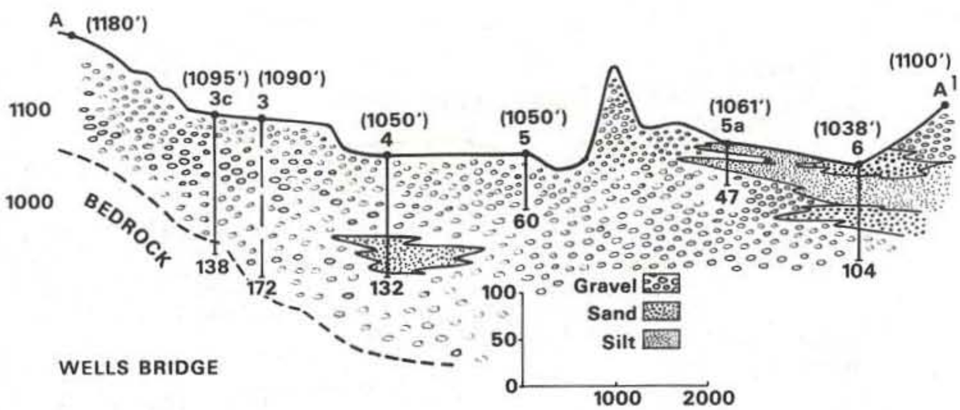


Figure 6

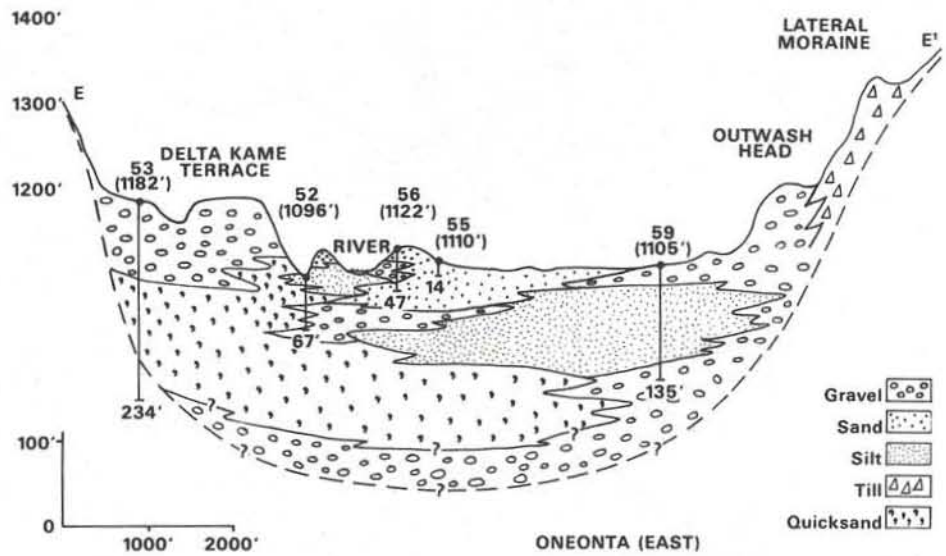
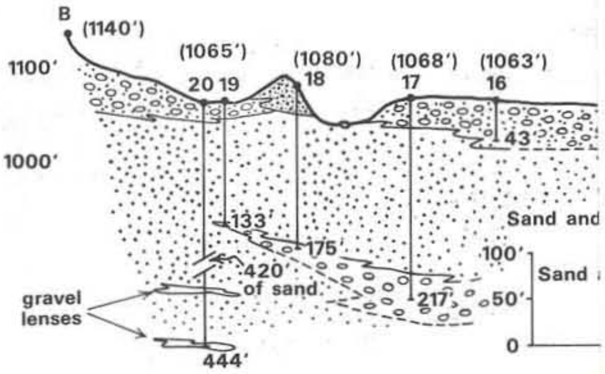
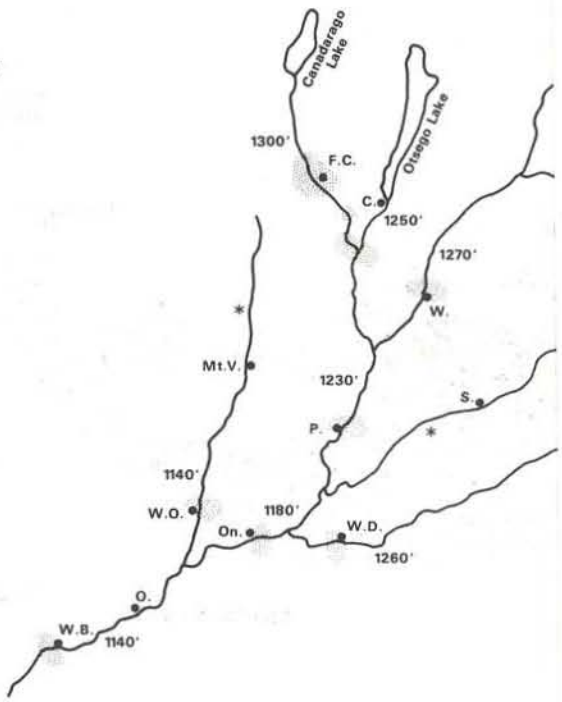


Figure 5



OTEGO

Figure 7



Miller, N. G., 1973,
in southwestern N
no. 420, 102 p.

Randall, A. D., 1972,
Susquehanna River
Conserv., Bull. 6

Rich, J. L., 1935, Gl
Bull. no. 299, 18

Sirkin, L. A., 1967,
Long Island and e
Quaternary Paleoe

Weir, G. P. and W. N.
Otsego County, N.
Station, Cooperst

Whipple, J. M., 1969,
to Richfield Spri
York, 130 p.

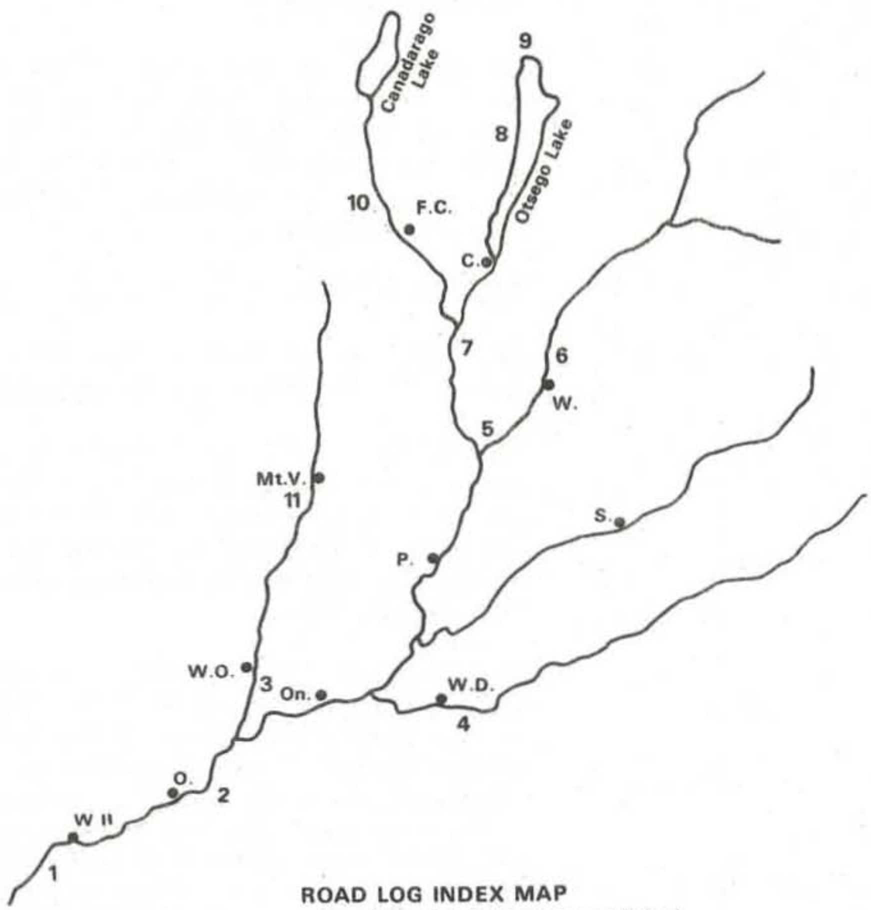
ROAD LOG: GLACIAL GEOMORPHOLOGY OF THE UPPER SUSQUEHANNA DRAINAGE

P. Jay Fleisher
SUNY, College at Oneonta

INTRODUCTION

The purpose of this field trip is primarily to examine the evidence for the glaciolacustrine environment at several different places along the upper Susquehanna drainage. The main stops will emphasize the landforms that characterize the salient aspects of a moraine impounded, ice-contact lake. Included will be various types of moraines and associated outwash, lacustrine plains, hanging deltas and delta-terraces, and strandlines.

The field trip will begin in Oneonta and cover the main Susquehanna Valley between Wells Bridge to the west and Oneonta to the east. The lower reaches of the Charlotte Creek Valley will also be considered. From there the route will mainly follow the Susquehanna north to its headwaters at Cooperstown, with a short diversion into Cherry Valley along the way. From Cooperstown the route will cross a short divide to the west and enter the drainage of Oaks Creek, and continue west and south to traverse the complete Otego Creek Valley. The road log index map shows the general location of each stop.



ROAD LOG INDEX MAP
(numbers indicate stop localities)

ROAD LOG
(Field trip log begins and ends at the
I-88 Oneonta [Rt. 23,28] interchange)

Miles from last point	Cumulative Miles	
0.0	0.0	Proceed west on I-88 from Oneonta (Rt. 23,28) interchange. I-88 parallels the Susquehanna River for the next 2.4 miles. Much of the area adjacent to the highway on the right (north) was under water during the spring flood of 1977 (probably a 25 year flood).
4.1	4.1	The valley floor to the north and south of the interstate was flood to within three feet of covering the highway here during the flood.
1.5	5.6	The highway rises above the valley floor and provides a good view of the modern flood plain and the abrupt change in valley trend that is a remnant of a preglacial engrown meander. The ridge on the horizon to the right (north) protrudes into the valley along the inside of the meander bend.
0.2	5.8	The location of STOP 1 is on the left (south), but we won't stop now. Access to this area is possible from County Rd. 48 (locally referred to as the Otego-Wells Bridge Rd.), which we will take on our return to the Oneonta area from Wells Bridge.
3.3	9.1	Continue west on I-88 past Rt. 7 & Otego exit.
1.3	10.4	Good view to the west of the valley plug formed by the Wells Bridge moraine.
1.7	12.1	View to the right (north) across the valley includes the back of the Wells Bridge moraine and associated outwash head terrace. The next 1.2 miles provides an excellent overview of the moraine and the breach carved by the Susquehanna River.
1.2	13.3 STOP 1	Exit I-88 into Rest Area. The eastern end of the parking lot looks over the hummocky relief on the down valley side of the moraine. The common border of the Franklin and Unadilla Quadrangles passes directly through the moraine. This moraine completely blocked the valley following glacier retreat permitting the damming of a continuous body of water, referred to as

Miles from last point	Cumulative Miles	
		Lake Otego, from Wells Bridge to Oneonta. Figure 3 of accompanying paper illustrates the topographic and subsurface aspects of the valley in this area. The moraine is assumed to have been implaced about 16,000 years BP and breached about 14,000 years BP. We will consider the field evidence for an 1140 feet lake level at the next two stops. Field work in the Unadilla and Sidney areas indicates that the Upper Susquehanna Lake Chain has greater down valley extent than will be covered in this road log. Return to I-88.
1.5	14.8	Cross Ouleout Creek.
0.5	15.3	Leave I-88 at exit for N.Y. 357, Franklin and Unadilla. Turn right on Rt. 357-West.
1.2	16.5	Cross Susquehanna River and turn right on Rt. 7 - east. Highway parallels the river for one mile.
1.7	18.2	Railroad overpass. Highway climbs onto outwash terrace near mouth of Sand Hill Creek.
1.8	20.0	Highway drops into Sand Hill Creek incision of outwash and immediately climbs to follow the Wells Bridge moraine - outwash contact.
0.6	20.6	Crest of moraine on the left, breach on the right.
0.4	21.0	Village of Wells Bridge. Turn right (south), cross Susquehanna and turn left (east) at the end of the bridge on Otego-Wells Bridge Rd., which becomes Otsego County Rd. 48. It was within the breach of this moraine that Bob Funk uncovered charcoal while excavating an archeological site in point bar silts that yielded a date of 13,000 to 14,500 years BP. This provides the younger limiting age of Lake Otego. Road parallels river for 0.6 miles before rising onto outwash head terrace. A correlative terrace can be seen across the valley to the north at an elevation of about 1140 feet.
1.1	22.1	Excavation for house on the right exposed fine sand under gravel with the contact at the base of the building, a few tens of feet below the terrace surface.

Miles from last point	Cumulative Miles	
1.9	24.0	Cross over I-88. White house across the valley to the north is situated on a terrace at about 1120 feet. Other planar landforms can be found along the valley that suggest a second level for Lake Otego below 1140 feet. This may be an interesting prospect to consider as a group. Entering Otego Quadrangle.
0.7	24.7	Access to I-88 on left. Continue straight ahead.
0.6	25.3	Fork in road, bear left.
0.3	25.6	Pass under I-88.
0.1	25.7	Intersection at end of bridge, turn right remaining on County Rd. 48.
0.2	25.9	Gravel excavation on right contains deltaic foreset and topset beds indicating current direction to the west down valley.
0.2	26.1	Similar exposure in excavation on the left.
0.6	26.7	Road drops to modern flood plain, which is superimposed on Lake Otego lacustrine plain. Lacustrine plain to the left and right for about a mile.
1.1	27.8	Kame on the right. Prior to construction of I-88 a similar but smaller feature could also be seen to the northeast.
0.2	28.0	Stop 2 is situated to the right, across I-88, on the lower valley wall slope marked by gullys and below "treeline". Proceed to I-88 overpass (.5 mile).
0.5	28.5 STOP 2	Park on the right beyond the overpass and walk south between I-88 and the forested slope of the valley wall. (Access permission may be requested at the farm directly across I-88 to the west.) Walk beyond the truncated spur to a gullied area on the left, about 300 yards south of overpass and upslope from the fence. At an elevation of approximately 1120-1140 feet (2/3 the way up the forest-free slope) pebbly coarse sand, fine sand, silt and a few clay seams were exposed along a gully wall in June 1977. Fluvial channel structures with

Miles from last point	Cumulative Miles	
		small scale foreset beds inclined into the slope and down valley rest upon finely laminated, rippled and cross bedded silt and fine sand. A distinct topographic break in slope can be seen up slope producing a clearly defined bench along the valley wall. A test pit to a depth of 2 to 3 feet revealed well sorted sand lacking stratification and containing occasional pebbles. This was noted repeatedly along this bench at an elevation of about 1140 feet. Another test pit upslope a few tens of feet and farther onto the bench revealed similar sand, lacking stratification as before, but no pebbles. These sands are interpreted to have formed along the strandline of Lake Otego by wave generated currents that moved into this valley wall alcove. The sand above 1140 feet lacks pebbles and is considered to be of eolian origin, blown up slope from the beach. Continue east on County Rd. 48.
1.3	29.8	Road drops back down to the lacustrine plain at an elevation of 1060 feet. Entering Oneonta Quadrangle.
1.5	31.3	Turn left on access to I-88,cross river and I-88, and proceed to Rt. 205 north.
0.5	31.8	Go straight through traffic light at Rt. 7 intersection. The highway traverses an outwash/alluvial bench between 1100 and 1120 feet at the confluence of Otego Creek and the Susquehanna River.
0.8	32.6	Continue straight through traffic light.
0.3	32.9	Junction of Rt. 23 from the right. Continue straight on Rt. 205-23.
0.7	33.6	Bear left on Rt. 23 at blinking light fork.
0.3	33.9 STOP 3	Turn right into gravel quarry just short of Otego Creek bridge in West Oneonta. The material exposed here has been consistantly similar to what can be seen here now. Massive foreset beds of coarse pebbly sand and washed gravel are inclined down valley and define to topographic slope to the south. Above are more poorly sorted topset gravels that vary in

Miles from last point	Cumulative Miles	
		thickness between 5 and 10 feet. The upper surface is planar and can be traced to the east, where it becomes irregular across Rt. 205. The northern side of the feature drops in elevation to join a terrace and eventually the flat, poorly drained valley floor. Interbedded and laminated silt and clay dominate this slope and show collapse structures. Occasional rafted clasts can be found within these deposits. By the nature of the material, its internal structure and topographic expression, this feature is referred to as the West Oneonta delta moraine. The topset-foreset contact is placed at about 1140 feet. Leave quarry and turn left on Rt. 23. Back track to Rt. 7 intersection and I-88 interchange.
2.3	36.2	Turn left on I-88 East and proceed to next exit.
2.7	38.9	Exit I-88 at Oneonta Rt. 23 and 28 interchange. Turn right on Rt. 28 East and cross river. Turn left (east) at stop sign on Rt. 28 East.
0.4	39.3	A large kame delta complex begins here on the right and continues for one mile. This may be part of a once larger delta moraine that extended farther into the valley.
1.0	40.3	To the right beyond the Holiday Inn and at the base of the valley wall can be seen the broad crest of a partially disserted left lateral moraine at an elevation of 1340 feet. Its up valley extent can be traced for about a mile, where it is in association with an outwash terrace (probably outwash head) at 1200 feet.
1.0	41.3	Both the moraine and the terrace can be clearly seen on the right (south). Coe Hill Rd. (dirt) crosses both of them and offers access. On the left (north) side of Rt. 23 is a lacustrine plain at 1100 to 1120 feet.
0.8	42.1	Highway climbs the kettled margin of the 1200 feet terrace. Kettles suggest an ice-contact origin. Within the next mile the highway will rise again on the down valley portion of the West Davenport moraine. Entering West Davenport Quadrangle.

Miles from last point	Cumulative Miles	
1.6	43.7	Intersection with road on the left that traverses the moraine across the valley and through the Charlotte Creek breach. The hummocky surface of the moraine can be seen along Rt. 23 as you proceed east.
2.5	46.2	Enter the downtown portion of Davenport Center and turn right (southeast) off Rt. 23 onto Delaware County Rd. 10 across from the general store. Proceed for 0.1 mile and turn left into gravel quarry within a hanging delta.
0.1	46.3 STOP 4	This excavation provides a look into a large hanging delta that was graded to Lake Davenport at 1260 feet. The lake was dammed behind the dual crested West Davenport moraine and flood the Charlotte Valley for a number of miles to the east. The difference between the internal sedimentary structures of this delta and those in a delta moraine reflects the contrasting sedimentary environments of the two. Here discharge is less variable, less sporatic and less energenic. Well sorted toeset sand displays a variety of delicate cross bedding, ripples and draped laminations reflecting the progressive decrease in current velocity and increase in water depth. The best exposures can be found along the northern portion of the excavation. Watch your step when climbing on the exposure and try to keep the dust down. Return to Davenport Center and intersection with Rt. 23.
0.2	46.5	Proceed straight across Rt. 23 and the clay rich lacustrine plain of Lake Davenport. Cross Charlotte Creek via two small bridges at 46.7 and 46.8, and bear left on Pine Lake Rd. Road climbs off the lacustrine plain and onto the back side of the dual-crested West Davenport moraine. Pine Lake is a kettle hole pond in the moraine.
0.4	46.9	Turn left at stop sign onto Delaware County Rd. 11. The road traverses the moraine, and part of the lacustrine plain for the next 3.2 miles.
2.2	49.1	Stop sign in West Davenport. The road to the left takes you back to Rt. 23, but we will proceed straight ahead on Delaware County Rd. 11.

Miles from last point	Cumulative Miles	
0.9	50.0	Entering Town of Oneonta. The road traverses part of the dissected and pitted outwash associated with the West Davenport moraine. The outwash surface blends with the 1180 feet terrace at the Susquehanna-Charlotte Creek confluence.
0.9	50.9	Morningside Drive on the left leads to the Oneonta Land Fill, where deltaic foreset beds within the 1180 feet terrace are inclined to the southeast indicating a current direction up the Charlotte Creek Valley. This is interpreted to mean the Charlotte was free of ice before the Susquehanna.
0.3	51.2	Entering Oneonta Quadrangle. Hemlock Rd. joins Otsego Co. Rd. 47 from the right. Proceed straight ahead. There are three large gravel excavations equally spaced north of Hemlock Rd. over a distance of two miles. Each reveals deltaic internal structure indicating current flow down valley and toward the valley center. Three distinct lobate aspects of the terrace here suggest coalesced lateral deltas that have formed a delta terrace at 1180 feet.
0.3	51.5	Cross Susquehanna River and I-88 interchange.
0.5	52.0	Intersection with Rt. 7 and 28 at Emmons traffic light. Turn right (east).
1.2	53.2	View across the valley to the south shows that the 1180 feet terrace position is nearly continuous across the valley floor. This illustrates the lobate nature of the terrace margins in this area and provides a view of the delta-terrace.
1.3	54.5	Entering West Davenport Quadrangle. Turn left at blinking traffic light (Lorenzo's Homestead Restaurant on the left) and follow Rt. 28 north.
0.8	55.3	Goodyear Lake on the right. Entering Milford Quadrangle.
1.5	56.8	Entering Milford Center, where well data from points across the valley indicate the bedrock floor lies more than 336 feet below the present lake level, and is predominantly occupied by quicksand.

Miles from last point	Cumulative Miles	
1.0	57.8	Enter Portlandville.
0.3	58.1	Turn right at Blue Bonnet Antiques and cross the Susquehanna River. Proceed across the poorly drained, pitted outwash for 0.2 mile and cross railroad tracks.
0.2	58.3	Turn left beyond tracks on Otsego County Rd. 35. For the next 2.4 miles we will be traversing the outwash and ablation moraine (Portlandville moraine) that dammed the Susquehanna to form Lake Milford at 1230 feet. This lake extended up valley to Hyde Park and into the mouth of the Cherry Creek Valley.
0.5	58.8	Wrightman Rd. intersects County Rd. 35 at white farm house and leads to the Crumhorn Mt. wedge locality discussed in this field guide under the title Wedge-Shaped Structures in Bedrock and Drift. In order to reach this site from here, take Wrightman Rd. and climb the valley wall for 1.1 miles; turn sharply to the left (northeast) on Boy Scout Rd. and follow the sign toward the Crumhorn Mt. Boy Scout Camp. Proceed northeast for 0.5 miles to a small rock quarry situated on both sides of the road. Park at the first exposure on the right. Although more than a dozen wedge structures were exposed during the progress of excavation only two remained clearly visible in June 1977. They can be found in a south-facing exposure on the east side of the road. Look for the characteristic upward flexure of bedrock that occurs adjacent to the wedges. In order to continue the road log mileage, back track and return to Otsego County Rd. 35. <u>The mileage to and from Crumhorn Mt. is not included in this log.</u>
3.0	61.8	Good view of the Lake Milford lacustrine plain to the left.
1.7	63.5	Stop sign intersection. For the past couple of miles the road has primarily been on the lacustrine plain. Turn left at stop sign. Proceed for 0.2 miles across Cherry Valley Creek and to intersection with Rt. 166.

Miles from last point	Cumulative Miles	
0.2	63.7 STOP 5	Intersection of Rt. 166 and County Rd. 35 Turn right and park. Exposed here on the west side of the highway is 33 feet of interbedded gray and tan clay under 14 feet of interbedded sand and coarse pebbly sand. The sand forms a discontinuous bench at 1230 feet and is interpreted as a Lake Milford strandline. Proceed north on Rt. 166.
1.5	65.2	Surface of hanging delta at 1230 feet formed by tributary to Lake Milford. False gain by alluvial fan deposition gives delta a gently inclined up surface.
1.5	66.7	Entering Cooperstown Quadrangle at the Cooperstown-Westville Airport. From here north for about 2 miles the highway is on pitted outwash.
1.5	68.2	Note morainic topography beginning to develop on the right.
0.4	68.6	Turn right onto Norton Cross Rd. (unmarked) that crosses Cherry Valley and traverses the hummocky surface of a moraine near Westville. This is the southeastern extension of the Cassville-Cooperstown moraine which is in the Susquehanna Valley to the west.
0.7	69.3 STOP 6	Cross Cherry Valley Creek where it breaches the moraine. Pull off to the right just beyond the bridge near the top of the hill. At the time of implacement this moraine blocked the valley to an elevation of about 1170 feet forming a dam for Lake Middlefield, a body of water that drowned Cherry Valley for nearly its entire course. The field evidence for Lake Middlefield is in hanging deltas at the mouths of tributary streams, a delta moraine at Middlefield and associated kame delta, and the large lacustrine plain across which the drainage presently meanders. In addition, well data indicate lacustrine sedimentation and the accumulation of thick clay deposits. The hummocky topography yields down valley to a pitted outwash that was incised by the drainage of Lake Middlefield to form valley train terraces. Up valley the moraine loses relief and joins the lacustrine plain.

Miles from last point	Cumulative Miles	
		Clean exposures in this road cut have revealed the moraine to consist of stratified sand and gravel and not unsorted drift. Proceed southeast across Cherry Valley on Norton Cross Rd.. Leave Cooperstown Quadrangle, enter Westford Quadrangle.
0.2	69.5	Turn left (north) at yield sign on County Rd. 35. Up valley extent of moraine can be seen on the left for the next 0.4 miles to where it finally joins the lacustrine plain.
0.8	70.3	Road crosses a dissected hanging delta at the mouth of a tributary. Barn on the left is situated on the delta surface at about 1270 feet.
0.4	70.7	Good view of poorly drained lacustrine plain.
2.1	72.8	Enter Village of Middlefield, turn left at stop sign and continue on County Rd. 35 to the northeast.
0.2	73.0	Cross Cherry Valley Creek and lacustrine plain.
0.1	73.1	Turn right on Moore Rd. just beyond the bridge and proceed north onto the front of a delta moraine.
0.1	73.2	Inactive quarry on right at one time revealed stratified sand and gravel with fluvial cross bedding. The road traverses the kettled back portion of the moraine for the next 0.5 miles.
0.5	73.7	Intersection with Rt. 166. Turn left and proceed southwest.
0.3	74.0	The hummocky slope on the right suggests the extension of the delta moraine at the base of the valley wall.
0.4	74.4	Dirt road on the left leads to a delta kame that can be seen standing above the lacustrine plain to an elevation of slightly above 1280 feet. Present excavation reveals distinct gravel foreset beds inclined down valley.
1.0	75.4	Road crosses a dissected hanging delta/alluvial fan at a B.M. elevation of 1275 feet.

Miles from last point	Cumulative Miles	
0.5	75.9	Turn right on Otsego County Rd. 52 to Cooperstown. Return to Cooperstown Quadrangle.
1.4	77.3	Road descends valley wall and provides a good view of morainic topography downslope. This may be the upland facies of the Cassville-Cooperstown moraine.
1.3	78.6	Enter Bowerstown. The road crossed morainic topography over much of the last mile. Turn left (south) on Beaver Meadow Rd.
0.7	79.3	Once again the road crosses what appears to be the upland facies of the Cassville-Cooperstown moraine. Note the morainic topography for the next 0.4 mile and discontinuously for the next 2 miles.
2.1	81.4	Stop sign. Intersection with County Rd. 33. Turn right.
0.3	81.7	Turn left on County Rd. 11 C (stonehouse and barn 100 yards down 11C). This is the outwash portion of the Cassville-Cooperstown moraine.
0.3	82.0	Railroad crossing and bridge over Susquehanna River.
0.4	82.4	Intersection with Rt. 28 at Hyde Park. Turn right (north).
0.3	82.7	Enter Village of Index.
0.4 STOP 7	83.1	Pull off to the right next to St. Mary's Cemetary. To the northwest (across the highway) is the characteristic topographic expressive for the Cassville-Cooperstown moraine. It can be traced in that direction for 5 miles up Oaks Creek to Oaksville. However, from here eastward across the Susquehanna Valley the moraine shows less relief, yet maintains an elevation of about 1250 feet. As the ice retreated from this position a lake remained impounded behind the moraine and grew in size. It is referred to as Lake Cooperstown and reached an upper limit of about 1250 feet. At this elevation it would have been somewhat larger than Lake Otego, which maintains an elevation of 1195 feet at present.

Miles from last point	Cumulative Miles	
		Well data from the vicinity of Hyde Park indicate the bedrock valley floor is in excess of 265 feet below the modern flood plain. The fill is almost entirely quicksand. This depth is consistant with gravity surveys run across the valley between the moraine and the Village of Cooperstown. Continue north on Rt. 28.
0.4	83.5	Moraine yields to outwash head and tributary deposits.
1.4	84.9	Enter Village of Cooperstown.
0.1	85.0	Bear right across railroad on Rt. 28.
0.4	85.4	Junction of Rt. 28 and Rt. 80. Continue straight on Rt. 80 east.
0.3	85.7	Traffic light at intersection of Rt. 80 and Main Street. Baseball Hall of Fame is two blocks to the right. Continue through intersection on Rt. 80.
0.1	85.8	Stop sign. Turn left.
0.6	86.4	Farmer's Museum on left, golf course and Otsego Lake on right. The golf course is situated on part of a small moraine and outwash surface that bulges slightly into the lake.
1.3	87.7	Beginning here and for the next 0.1 miles the road crosses a partially dissected and incised hanging delta at Brookwood Point. The most easily recognized strandline features of Lake Cooperstown are found along the western side of the valley where tributary drainages are larger.
1.1	88.8	Three Mile Point. Large brown and yellow house on the left occupies the surface of a hanging delta at an elevation of about 1250 feet.
0.7	89.5	Enter Richfield Springs Quadrangle.
0.8	90.3	Road climbs onto the hanging delta at Five Mile Point, which also stands at about 1250 feet.
1.0	91.3 STOP 8	Pull into the small parking area on the right next to the sign for the Lakeview Motel and

Miles from last point	Cumulative Miles	
		Cottages. Cross Rt. 80 and walk to the excavation at the back of the Lakeview Motel. Distinct foreset-topset structure can be seen in very coarse gravel. The upper surface was measured to be 66 feet above Otsego Lake and determined to have an elevation of about 1255 feet. This being the distal end of the delta lobe there is probably a minimal addition of false gain. Directly across the lake is Hyde Bay, into which Shadow Brook drains. A gravity survey run across that valley just 0.1 miles from the bay indicates a depth to bedrock of 69 feet. A single water well 0.2 miles up Shadow Brook logged 8 feet of gravel and 62 feet of clay, silt and sand, with the lower contact of the gravel at 1247 feet, indicating that Lake Cooperstown rose to at least that level. Furthermore, Shadow Brook flows across bedrock just 0.5 miles from this well, suggesting a buried channel up valley from Hyde Bay. Proceed north on Rt. 80 past Six Mile Point, which is also situated on a hanging delta graded to the level of Lake Cooperstown.
0.3	91.6	Enter Town of Springfield.
1.4	93.0	Rt. 80 traverses another hanging delta at about 1250 feet for 0.4 miles and shows a good example of modern incision. From here north the valley widens and relief diminishes. This is the open end of the Susquehanna through valley.
1.7	94.7 STOP 9	Turn right on Otsego County Rd. 53 and park. Walk back to intersection and clean up drainage ditch on southern side. Extremely fine laminated clay in varve-like form was exposed in June 1977. The elevation here is 1220 feet, which would have placed this area under about 30 feet of Lake Cooperstown water. Since leaving the Otsego Lake trough 2 miles back the terrain has become much more subdued and gentle. The modern sedimentary condition along the northern lake shore is considered to be a good analog of the environment in which these clays accumulated. Turn around, turn left and back track south on Rt. 80.
4.2	98.9	Five Mile Point. Turn right on Otsego County Rd. Rt. 28.

Miles from last point	Cumulative Miles	
0.8	99.7	Stop sign. Turn left, still on County Rd. 28.
2.0	101.7	Turn right at white house onto Armstrong Rd. (unmarked). SPCA sign at intersection.
1.8	103.5	Turn right at Tanner Hill Rd. (unmarked).
1.2	104.7	Road ends at intersection with County Rd. 26 (unmarked). Turn left. Road descends into the valley of Fly Creek.
1.1	105.8	Cross Fly Creek and the lacustrine plain of a small lake that was ponded behind a moraine at the Village of Fly Creek 3.5 miles down valley (to the left).
0.6	106.4	Bear left and remain on County Rd. 26. Road now parallels the valley and provides a good overview of the lacustrine plain on the left.
1.7	108.1	Enter Cooperstown Quadrangle.
0.3	108.4	Road climbs a moraine and follows it for 2 miles to Village of Fly Creek. This is part of a large moraine complex that blocked the drainage at Fly Creek and Oaksville.
2.0	110.4	Enter Fly Creek. Stop sign at intersection with Rt. 80 and 28. Turn right. Proceed west along the continuation of the moraine to Oaksville. This is the western extension of the Cassville-Cooperstown moraine that blocked Oaks Creek and dammed Lake Oaksville in the Canadarago Valley.
0.7	111.1	Enter Oaksville and Hartwick Quadrangle.
0.3	111.4	Cross Oaks Creek.
0.3	111.7 STOP 10	Pull off to the right and walk into the gravel quarry situated toward the back side of the moraine. Exposed are sorted and stratified sand and gravel, as is typical of moraines in the upper Susquehanna. Although the surface expression is hummocky and irregular, massive foreset beds characterize the internal structure of this part of the moraine. Possibly this accumulated in a delta moraine fashion as the ice retreated from the main moraine position.

Miles from last point	Cumulative Miles	
		The moraine reaches an average elevation of between 1300 and 1320 feet and controlled the water level in Lake Oaksville. Strandline features at this position can be seen in a number of places around Canadarago Lake and at Richfield Springs to the north. Although Canadarago is much smaller and shallower than Otsego Lake (44 feet vs. 166 feet), well information and gravity data indicate it occupies a bedrock basin comparably deep. Proceed north on Rt. 80 and Rt. 28.
0.4	112.1	Road descends back of moraine. Lacustrine plain of Lake Oaksville lies ahead.
0.2	112.3	Turn left and remain on Rt. 80 west and Rt. 205 south. Road climbs off the lacustrine plain and across the divide to the drainage of Otego Creek.
1.9	114.2	Turn left on Rt. 205 south.
2.8	117.0	Road descends onto flat floored valley.
0.7	117.7	Two kames and an area of dead ice topography can be seen on the left.
1.2	118.9	Cross Otego Creek and enter Village of Hartwick. Continue south on Rt. 205.
1.1	120.0	Truncated spur on left as road climbs large hummocky terrace form. This terrace, which continues for about a mile, appears to be a complex of dead ice terrain and tributary fan/delta deposits from adjacent short valleys.
1.1	121.1	Road drops to valley floor and what appears to be a lacustrine plain. Enter Mt. Vision Quadrangle.
2.4	123.5	Road climbs a bedrock controlled terrace and continues across a glaciofluvial terrace of uncertain origin. This and other similar features can be seen repeatedly along the valley. They are thought to be associated with static or stagnant ice condition that characterized this drainage.
0.9	124.4	Enter Town of Mt. Vision. Continue south on Rt. 205.

Miles from last point	Cumulative Miles	
1.8	126.2	Turn to the right on Blood Mills Rd. (unmarked), just short of sign for Circle S Farm.
0.3	126.5	Cross Otego Creek and turn right on dirt road that parallels the creek. Road leads to Otsego County gravel quarry.
0.2	126.7 STOP 11	Unload at gate and walk in. At various times during excavation a consistantly well defined deltaic internal structure has been observed. Massive foreset gravel and sand dip down valley and are covered by more poorly sorted topset beds, which range in thickness up to 30 feet. This deposit is practically at the center of the valley and has lateral extent. The creek cuts through to the east, where it is forced against the base of a truncated spur. A small tributary enters the valley from the west and joins Otego Creek slightly to the north. This feature has the topographic expression of a hanging delta at an elevation of about 1200 feet, but may well be part of a delta terrace deposit or kame delta. Collapsed wedge-shaped structures have been found at various times in the topset beds. Their occurrence and possible origin are discussed in this guidebook under the title Wedge-Shaped Structures in Bedrock and Drift. Return to Rt. 205.
0.4	127.1	Turn right on Rt. 205 south. The road crosses an extensive and continuous terrace level from here south to Laurens and beyond. The terrace scarp maintains an irregular trend marked by several undercut banks where the creek has meandered against the base of the terrace. In spite of this the terrace scarp expresses a lobate trend unrelated to meander scars. This feature is interpreted as a delta-terrace formed by terminal discharge in an ice-contact lake and not considered to be a kame terrace.
2.9	130.0	Highway traverses a small moraine that extends into the valley and deflects Otego Creek westward.
1.9	131.9	View of lacustrine plain to the right. Enter Oneonta Quadrangle.

Miles from last point	Cumulative Miles	
1.6	133.5	Highway crosses the lateral extension of the West Oneonta delta moraine, which can be seen to the right.
0.2	133.7	Junction of Rt. 205 with Rt. 23 at stop sign and blinking red light. Bear left and proceed south.
1.9	135.6	Traffic light intersection with Rt. 7 and I-88 interchange. Proceed across Rt. 7 to I-88.
0.3	135.9	Turn left on I-88 East.
2.7	138.6	Exit I-88 at Oneonta (Rt. 23 and 28) interchange.
		END OF FIELD TRIP