GEOMORPHOLOGY OF THE CAYUGA LAKE BASIN

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GEOMORPHOLOGY

The Finger Lakes Region of Central New York is justly famous for two aspects of its geology: the Devonian stratigraphy and the Quaternary geomorphology. Not as well appreciated is the fact that the Quaternary landscape is the result of 360 million years of post-Devonian erosional history, for which no stratigraphic record is available in the region. An enormous uncomformity everywhere separates glacial drift of late, or at the oldest, middle Pleistocene age, from the underlying lithified and mildly deformed Devonian marine strata. Volumes of sediment on the North Atlantic continental shelf and rise imply at least 2 km of regional denudation in the Cenozoic Era (Mathews, 1975). The remaining Paleozoic section in the Finger Lakes region is little more than 2 km thick, so at least half of the depositonal section is gone. With a regional southward dip of about 1 per cent, 2 km of vertical denudation involved 200 km of homoclinal shifting of the present north-facing escarpments. The landscape viewed from the hill tops around Ithaca has a grand story to tell, when we can learn to listen.

The key to the geomorphology of the Finger Lakes Region lies in the geometry of deposition, deformation, and denudation. The Upper Devonian sedimentary facies were deposited in an epicontinental sea with a rising source area to the east; facies boundaries trend northeast to southwest, with Catskill facies alluvial-plain redbeds to the east, nearshore marine sandstones next to the west, and these grading westward into shales. Post-depositional regional deformation gently folded the Devonian rocks along fold axes trending N70°E, significantly shortened the sedimentary pile in a N-S direction (Engelder, this volume, and references therein), and regionally tilted the pile southward about one-half degree (1 per cent, 10 m/km, or 50 ft/mi).

The upper Paleozoic rocks of New York State record no significant source area to the north. The exposure of the Canadian Shield and Adirondack Highlands is therefore post-Devonian, although the former northward extent of Devonian sedimentation onto the continental platform is unknown. By Cenozoic time, the rivers of eastern North America were probably adjusted to structure on a regional scale. An intercuesta lowland (now Lake Ontario) should have followed the Ordovician shale belt between the shield and the Lockport dolomite escarpment. An ancestral Hudson River probably was eroding headward along the Hudson Valley shale belt at the base of the Shawangunk and Catskill escarpments, and at its head ancestral Mohawk and Lake George lowlands probably were forming on shale belts broadly concentric to the Adirondack highlands. If the present is a key to the past, regional erosional denudation was accomplished primarily by homoclinal shifting of subsequent (strike-oriented) rivers along shale lowlands.

On the southern dip slopes of Upper Devonian shales, siltstones, and sandstones in central New York, regional dendritic south-flowing rivers can be reasonably inferred. River gradients should have been significantly less than the regional dip, so dipping strata would be truncated by erosion in progressively younger belts from north to south. Kindle (1909, Fig. 21) noted long ago that the highest area between Cayuga Lake and Seneca Lake (Connecticut Hill in Enfield, height 2099 ft) is a synclinal ridge, demonstrating topographic inversion of relief even on the gentle structures of the region.

Several fossil peneplains have been proposed for the uplands of the Finger Lakes Region (Cole, 1938, 1941; Fridley, 1929). The evidence is fragmentary, but a reductionist logic still permits: (1) a structure-beveling ancient surface of low relief (and possibly near sea-level) now represented by the numerous summits in the region that range in height between 1800 and 2000 feet above sea level; (2) a lower structurally controlled surface primarily on shales at about 1000-1200 feet above sea level, and (3) various erosional levels within valleys below the two regionally correlative upland surfaces. Ignoring several generations of scholarly research, we can suppose that the gentle regional uplift that created south-draining dip-slope river systems also initiated the subsequent river systems along shale belts and started a long history of homoclinal shifting and lateral migration of divides toward the south. Ever since an early stage of regional erosion, north-flowing escarpment streams would have had steeper gradients than their south-flowing dip-slope conterparts, and the cuestas should have been migrating southward.

Probably by late Cenozoic time, the region had evolved to a "broad valley" stage, with valley floors graded to a regional level now 900-1000 feet above sea level. Uplift (Cenozoic tectonism in New York?) rejuvenated the rivers, and a "deep stage" of intrenched inner valleys resulted, especially along the axes of the north-flowing escarpment streams (von Engeln, 1961, p. 15). These valleys became the precursors of the Finger Lakes. Presumably the rejuvenation caused more rapid divide migration toward the south. It has long been noted that barbed tributaries are common in the Finger Lakes, with acute junction angles of drainage systems pointing south but now draining north. Near Ithaca, both Salmon Creek and Fall Creek show this pattern; Keuka Lake is a Y-shaped glacially eroded lake basin that outlines a pair of southward-merging ancestral river valleys, although it now drains north to the St. Lawrence along with all the other Finger Lakes.

Glacial erosion and deposition has massively modified the ancestral fluvial systems that drain northward, converting north-trending valleys into glacial troughs or rock basins, many of which contain finger lakes. However, the glacial lowering of summit levels was minor (Muller, 1963, p. 236), and the position of the regional St. Lawrence-Susquehanna divide may not have shifted very much by glacial processes. The evidence is weak, but the zone of highest summits across New York south of the Finger Lakes usually crosses the intervening valleys within a few miles of the present divide in each valley. The divide regions were reamed out by glacial erosion and associated proglacial and ice-marginal meltwater drainage, creating the famous "through valleys" that are the distinctive geomorphic feature of the region, much more so than the trough lakes, which are common in glaciated regions (Tarr, 1905, p. 233). One brief published report concluded that the massive Valley Heads moraine at Tully, New York, which forms the surface-water divide between Onondaga Creek to the north and the Tioughnioga system to the south by a barrier with 600 feet of relief on its northern, proximal, face, may rest on a bedrock sill at a depth of only about 220 feet (Durham, 1958). The rivers that drain south from the divide flow on valley trains that are not deep over bedrock. Their valleys were straightened by glacial erosion, but not much deepened. As most Valley Heads moraines in central New York crest at about 1200-1400 feet above sea level, the inferred bedrock sill beneath them may well be at about the 1000-ft. level that characterized the preglacial heads of the south-flowing drainage systems.

The hanging valleys and gorgeous gorges of the Finger Lakes Region are the result of glacial overdeepening of the main north-draining valleys that had notched into the northern edge of the Allegheny Plateau in preglacial time. The lateral (east-west) tributaries lay athwart the dominant direction of ice flow and were subject more to glacial and glacio-fluvial deposition than to glacial erosion. The series of valleys that converge at Ithaca (Fig. 1) make the point very nicely: north-oriented Inlet Valley and the Cayuga Lake trough are eroded down to below sea level; northwest-trending Sixmile Creek Valley and Cascadilla Creek Valley ("Ellis Hollow") have deep glacial-lacustrine fills on their floors but expose bedrock in places at about 950 feet above sea level; Fall Creek, which flows west, has a few areas of exposed bedrock at about 900-950 feet above sea level but masses of glacial drift fill most of the preglacial valley. The depth of glacial erosion seems directly related to the degree that each valley funneled the advancing tongues of successive continental ice sheets.

How many glaciers have covered Ithaca? From the deep sea oxygen-isotope record, one can safely infer 20 ice ages of similar intensity to the last one, each lasting about 100,000 years. The classic 4-fold midwestern glacial subdivision of the Pleistocene is as obsolete as pre-plate tectonics land bridges and Atlantis, but the Finger Lakes Region has revealed little of its glacial past. A pre-Wisconsin valley fill at "Fernbank" on the west side of Cayuga Lake demonstrates that a gorge had been eroded previously, probably by a minor tributary that had incised the valley side after an earlier glacial event had deepened Cayuga trough (Bloom, 1967). Therefore, at least two and possibly three glacial events can be inferred, depending on some assumptions. "Old", noncalcareous glacial drift is exposed at times along Sixmile Creek and at the head of Beebe Lake. If this drift is pre-Wisconsin, then the valleys around Ithaca were already as big as they are at the present prior to two ice ages ago. To the extent that their shape is due to glacial erosion, at least a previous third ice age must be inferred. The multi-reflecting subbottom seismic profile of Seneca Lake (Fig. 2) also implies that a long history of glacial erosion and deposition shaped the present catenary cross section of the Seneca Lake basin.

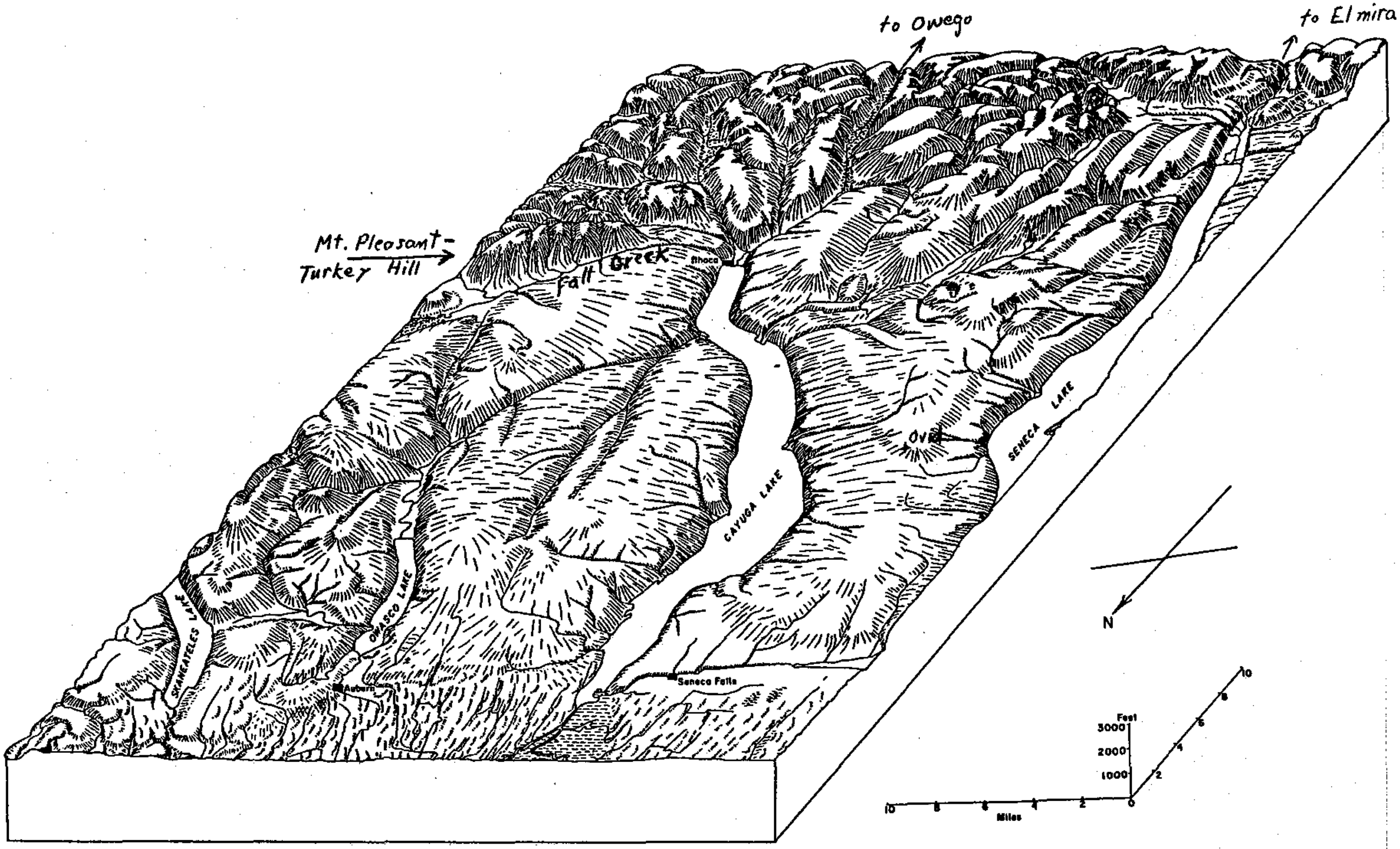

Figure 1. Physiographic diagram, Cayuga Lake basin (source unknown).

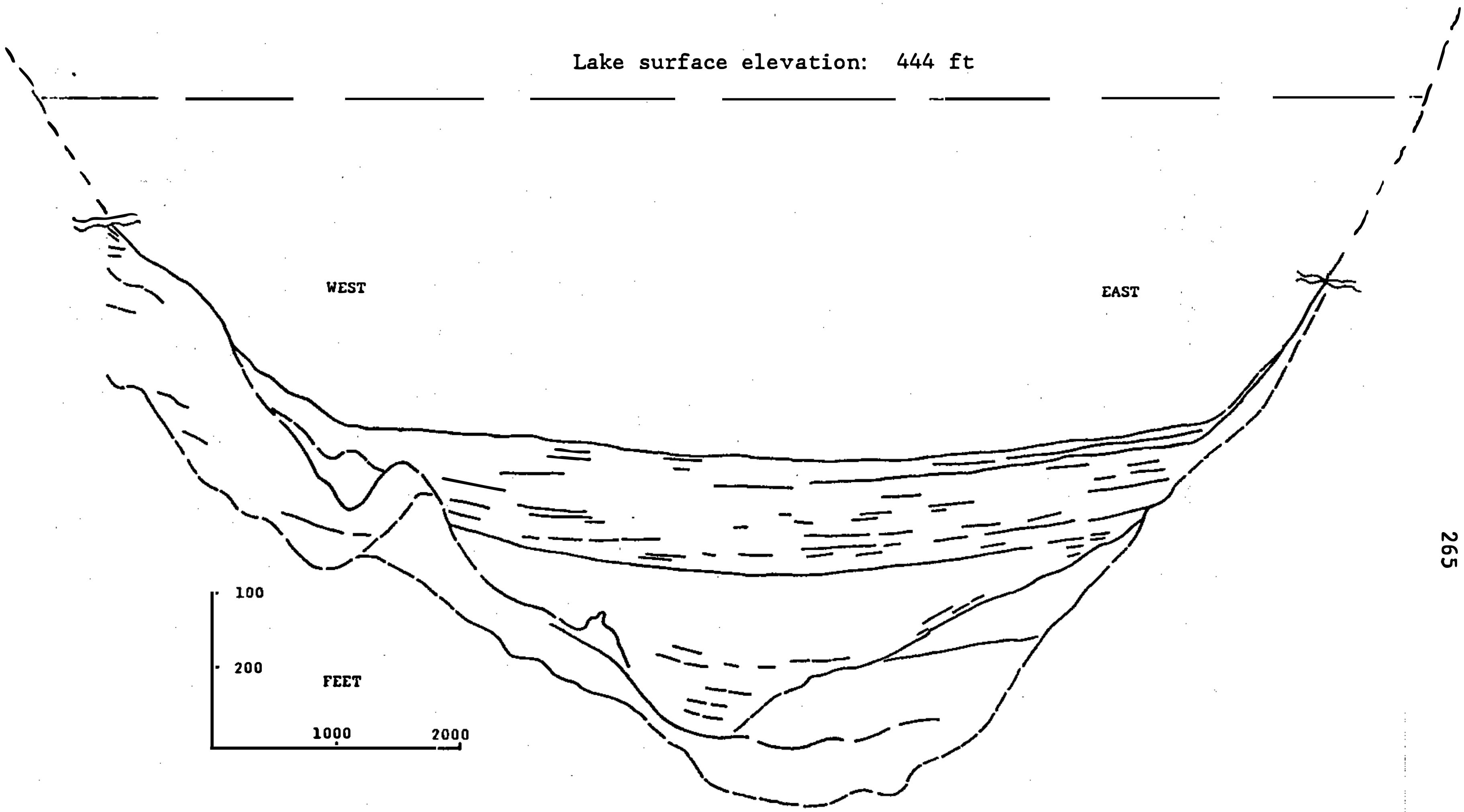

Figure 2. A seismic reflection profile across Seneca Lake based on data from a study for the Naval Research Laboratory. Maximum depth of the lake is 475 ft along this profile. Deep reflections are from sediment layers at least 500 ft below sea level. Vertical exaggeration X7 (adapted from a diagram by C. Windisch, in Woodrow, et al., 1969).

As we approach the present, the record of geomorphic evolution of the Finger Lakes Region becomes more readable. Most of the tributary valleys of Cayuga Lake near Ithaca were aggraded by a variety of glacio-fluvial and glacial-lacustrine deposits as the Wisconsin ice sheet advanced southward against the regional drainage. Rising proglacial lakes overflowed to the south across the divides, but most of the sediment remained within these great settling basins. Schmidt (1947) counted approximately 1000 annual couplets (varves) in Sixmile Creek Valley, grouped in four series that progressively thicken upward and show an increase in the thickness of the winter layer. The height of these deposits above the Cayuga Valley floor suggests that an ice lobe completely blocked the north end of the lake; the 1000 layers, if annual, suggest that the ice advanced about 40 miles (65 km) in 1000 years or about 65 m/yr. A finite radiocarbon date of 41,900 years from near the base of Schmidt's varve sequence has been correlated with a post-Plum Point Interstadial ice advance by Dreimanis and Goldthwait (1975). This date and several other "dead" radiocarbon analyses confirm that at least one mid-Wisconsin ice advance reached or affected the Finger Lakes Region. Little more can be said, now.

The final push of Wisconsin ice crossed Ithaca and moved south to the vicinity of Williamsport, PA. The age of that terminal position is still debated, but 17,000 to 19,000 years will be my educated guess until my southern colleagues agree on each other's evidence. The much favored relationship for the gradient at the edge of ice sheets, $h=4.7\sqrt{d}$ (h = ice thickness in meters, d = distance into the ice sheet from its margin, also in meters) yields a thickness of 1880 m of ice over Ithaca when the ice margin was 160 km to the south near Williamsport. Certainly, at this stage all the topography around Ithaca (maximum relief 2000 ft or 600 m) was deeply buried by ice.

By 13,000-14,000 years ago the ice margin had retreated to the regional divide south of the Finger Lakes. Here the ice edge paused or fluctuated, fed by a thickness of 1000 m or more of ice moving uphill toward the divide from the north, but unable to sustain glacier tongues down the Susquehanna system valleys. Here it built the Valley Heads moraine system, a series of massive morainic debris piles that choke the floors of the through valleys and with few exceptions determine the modern surface divide between the Susquehanna and St. Lawrence Rivers. With the progressive retreat of the ice margin northward from the Valley Heads moraine systems, the ice margin became more and more lobate and confined to the valleys. The South Cortland moraine, for example, was made by a distributary sublobe of the Cayuga Lake lobe that flowed northeastward for at least 12 miles from its base at Ithaca. The outwash from the South Cortland moraine flowed northeast and east to Cortland, where it merged with the valley train down the Tioghnioga Valley from the Tully moraine. Near-contemporaneity of several of the Valley Heads moraines in adjacent valleys can be demonstrated by similar relationships.

Once north of the Valley Heads position, the retreating lobate ice margin terminated in proglacial lakes in all the valleys. All but the suspended fine silt and clay-sized sediment was trapped in the lakes. Notable around Ithaca is the pink or brown colors of the post Valley Heads lacustrine beds. The color is derived from the Silurian red shale belt across the north end of Cayuga Lake, fully 40 miles away. The reddish sediments contrast sharply with the local sediment derived from gray-colored source rocks, so the abandonment of a south-flowing meltwater channel in favor of a lower western or eastern outlet, such as the rock gorges at Syracuse, is marked in the Ithaca region by an abrupt change from reddish to grayish sediments. The change is usually at a shallow depth, sometimes almost within the modern soil profile.

Deglaciation of the Cayuga Basin was even more rapid than earlier generations of geologists suspected (Fullerton, 1980). If the Valley Heads moraines are 13,000-14,000 years old and the St. Lawrence lowland was ice-free and open to the Champlain Sea by 12000 years ago, less than 2000 years were required to deglaciate the northern two-thirds of New York State! Some 10 or 15 names have been given to the sequence of hanging deltas in the Cayuga basin that record the episodic drop of proglacial lake levels, so each delta must have been built within a century or two. While the internal structure of the hanging deltas, with thick-bedded foreset gravel layers at angle of repose and only minor bottomset and subaerial topset beds, confirms rapid progradational growth, probably no geologist of the pre-radiocarbon era would have attributed their formation to a century time scale.

The river terraces and abandoned meanders along Fall Creek near Ithaca tell a similar story of rapid evolution. The oldest and highest surfaces record deposition or erosion in a variety of ice marginal streams or lakes, but with the integration of local lakes into glacial Lake Ithaca (outlet elevation 980 ft), lacustrine sediments and related hanging deltas and river terraces become reasonably correlative. A series of terraces near Varna record the dissection of the floor of local Freeville-Dryden Lake (elevation 1060 ft.) by Fall Creek as the creek cut down to the level of glacial Lake Ithaca and lower levels. The terraces should project down-valley into the surfaces of the appropriate hanging deltas, but the uncertainty of the channel gradients and the rapidity of changing levels make detailed correlation unlikely. The most significant fact is that <u>all</u> the terraces and hanging deltas were cut or built within one or two thousand years, at least 12,000 years ago. Soil profiles on the surfaces should differ more because of parent material, vegetation, and slope than because of climate or time. All the terraces' surfaces around Ithaca probably had soils forming through the late-glacial and postglacial times of the tundra (?), spruce, pine, and hardwood forest succession.

As the late-glacial gorge entrenchment encountered buried bedrock spurs and former valley floors, further downcutting was severely inhibited. Postglacial gorge cutting has proceeded downward for a few tens of meters and headward for some hundreds of meters, but most of our landscape has probably not changed much for 12,000 years. Even the impressive headward retreat of Fall Creek at Ithaca Falls, Enfield Creek at Lucifer Falls, or Taughannock Creek at Taughannock Falls may have been accomplished primarily by the re-excavation of preexisting valley fills left by earlier glaciations. The landscape we see on excursions around Ithaca was shaped in a brief interval of intense activity and rapid change about 14,000-12,000 years ago. Mastodons and Paleo-Indians walked on the same landscape that we now stroll.

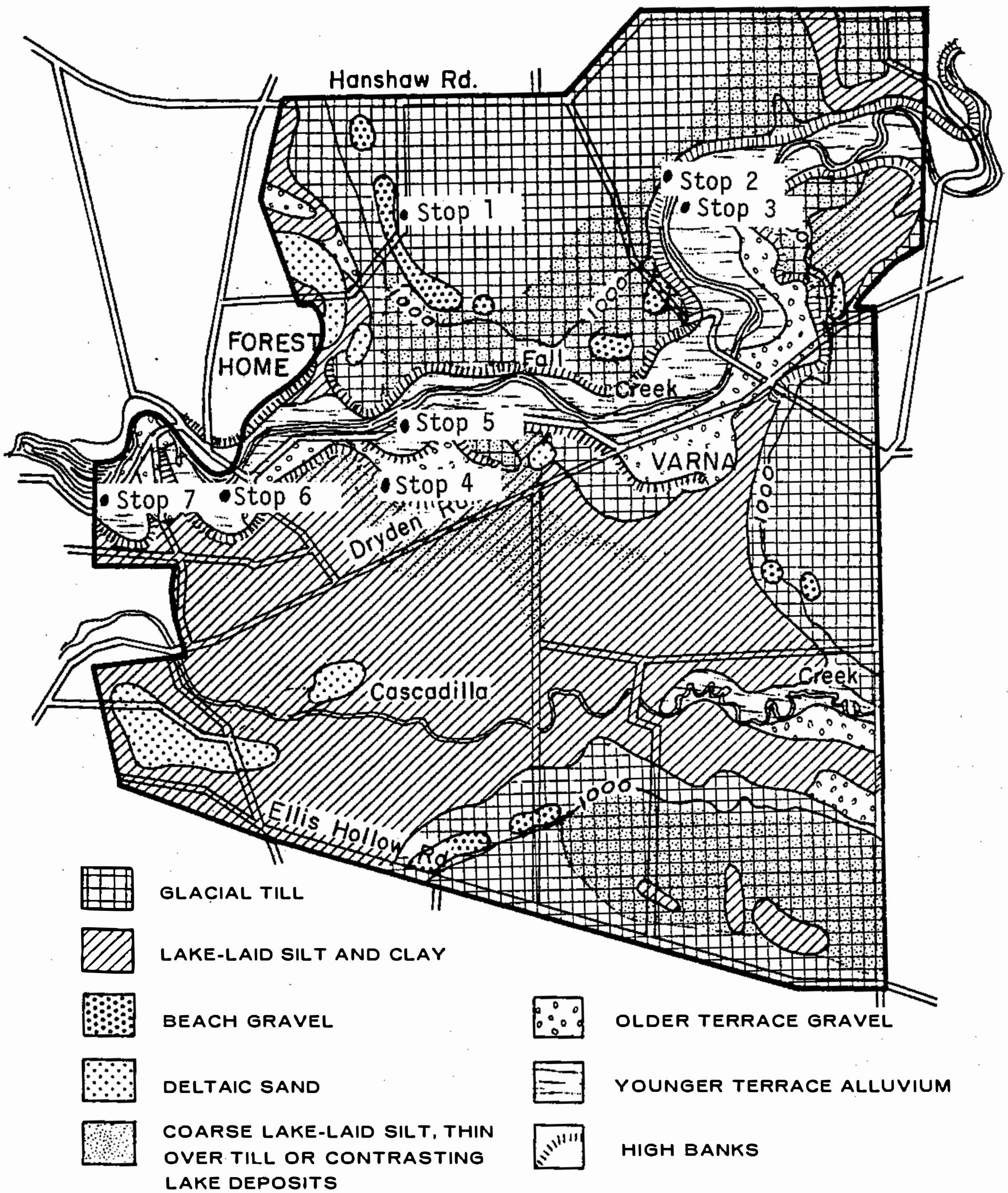

Figure 3. Locations of stops 1-7, and the parent materials of soils east of the Cornell campus (Cline and Bloom, 1965, Fig. 1).

LOCAL DESCRIPTIONS (SEE FOLLOWING ROAD LOG FOR ROUTES)

Stop 1. Lake Ithaca beach ridges near the Equine Research Laboratory.

In the course of making a detailed soils map of the Cornell campus area at a scale of 6.7 inches to 1 mile (~1:9500), Professor M.G. Cline and his students defined several areas with narrow ridges of well-sorted pebble gravel that are uphill from typical lacustrine silt-clay units of glacial lake Ithaca, and are downhill from non-lacustrine stony till soils (Cline and Bloom, 1965). The site along Bluegrass Road (Fig. 3) is typical. The pebbly soils are well drained, fertile, and warm, and have been allocated to small garden plots for Cornell staff and students. Downslope in the Cornell fields is a poorly drained belt of wet, cold soils, and across Bluegrass Road to the east is typical thin upland till, probably only a meter or less deep to bedrock. The gravel ridge was interpreted as a beach ridge of glacial Lake Ithaca, correlative with the 980-ft overflow south of Brooktondale at Belle School Road (Stop 9). A similar setting and soils sequence crosses Ellis Hollow Road and Game Farm Road along the base of Snyder Hill.

The beach ridge here is at an elevation of about 1020 ft; the similar ones in Ellis Hollow are about 1000 ft above sea level. The two beach ridge localities are 8 miles and 6 miles north of the 980-foot overflow, so the present gradient of the Lake Ithaca shoreline rises northward at 3 to 5 ft/mile. Possible causes include: (1) downcutting of the outlet during the life of glacial Lake Ithaca; (2) hydraulic gradient southward through the outlet (unlikely for a large, deep lake); (3) gravitational attraction of the water body northward toward the still extant ice mass; or (4) postglacial isostatic recovery increasing to the north. The tilt was aggressively debated by earlier geologists. Professor O.D. von Engeln gently referred to "a cult among geologists interested in the high levels of proglacial lakes which adheres to the concept that a postglacial northward uplift of the land made the original shore lines of the lakes rise toward the north" (von Engeln, 1961, p. 93). He went on to argue correctly that the correlation of delta tops from one tributary valley to another is much too indefinite to justify calculating a tilt. Perhaps he would soften his view if he could see the evidence we see today (or perhaps he would not!).

Stop 2. Top of the Varna high bank.

Fall Creek valley at this cross section is filled by a variety of Pleistocene sediments to be viewed in better perspective from stop 3. During the detailed soil mapping of the Cornell properties, Prof. Cline and his students noted the silt enrichment of the soil profiles in the fields north of this locality, and tentatively attributed it to an influx of eolian silt and sand in late glacial time. To their credit, the soils mappers noted that their eolian hypothesis did not fit the observation that the silt enrichment was found only below the 1060-ft contour. As long ago as 1934, H.L. Fairchild had named a shallow ice marginal lake called Freeville-Dryden Lake in the Fall Creek valley, which overflowed south around the west end of Mt. Pleasant into Cascadilla Lake and through the southeast end of Ellis Hollow (along Thomas Road, southeast corner of the Ithaca East topographic map.) The overflow is just above 1060 ft

(Fairchild's contour maps were in error), so Freeville-Dryden Lake must have been quite shallow and muddy, and it probably provided a minimal gradient for the ancestral Fall Creek when an ice wall to the west finally calved and drained Freeville-Dryden Lake down from 1060 ft into Lake Ithaca (in this region, at or below 1020 ft). The lowering of the local base level probably initiated a headward-migrating nick point across the exposed floor of Freeville-Dryden Lake and initiated the postglacial evolution of Fall Creek valley.

Stop 3. Base of the Varna high bank.

The high banks along Fall Creek north of Varna show the glacial stratigraphy. The lower half of the undercut bank over 100 feet in height exposes poorly sorted, crudely stratified sand and gravel. About 90 percent of the pebbles in the gravel are sandstone and shale of local derivation, and about 10 percent are limestone and crystalline erratics from the north. The sand, silt and clay matrix of the gravel is strongly calcareous. This stratified sand and gravel records the damming of lower Fall Creek by ice spreading eastward out of the Cayuga trough, while the headwaters of the creek were still ice-free.

Overlying the sand and gravel is about 40 feet of compact till that records the advance of ice up or across Fall Creek valley. Only about 70 percent of the till pebbles are of local origin, and most of the remaining 30 percent are limestone or dolomite. The tough, blue-gray matrix of the till is strongly calcareous. A thin layer of lacustrine sedimnts caps the oxidized upper part of the till.

As the succession of proglacial lakes in the Cayuga trough gradually fell to the level of present Cayuga Lake, Fall Creek has energetically re-excavated its interglacial valley. The thin cap of silt from Freeville-Dryden Lake was cut through while Lake Ithaca still drained through Willseyville Creek. Subsequently, Fall Creek established its postglacial course down the side of the Cayuga trough, soon to become superposed across buried rock spurs to give the succession of gorges and falls along the north edge of the campus. North of Varna, Fall Creek has not yet exposed its former rock floor.

Most of the cross-sectional area of the Fall Creek valley fill seems to be stratified sand and gravel. Roughly, the cross-section area of the modern valley on this transect is one-half as wide and about one-half as deep as the interglacial valley. Further downcutting has been inhibited by superposition on buried rock farther downstream (stop 5), but lateral migration has been extensive. The "Varna moraine" of Tarr (1909b, p. 151) and von Engeln after him, is only a cut bank of the valley fill. The "proximal" face of the "moraine" exposes a layered stratigraphy similar to that in the high bank.

In Fall Creek valley near Beebe Lake, and at several places along Six-Mile Creek, are exposures of non-calcareous, clay rich diamictons in which the few remaining granite gneiss pebbles and cobbles are totally "rotten". It seems clear that most of the valley cutting in bedrock around Ithaca predates at least two glaciations, although most of the earlier drift filling was removed and replaced by calcareous drift of probable Wisconsin age. An interesting applied aspect of the layered valley fill is that any dams across Fall Creek or other rivers in the Cayuga basin would involve a high risk of leaking through the coarse alluvial members of the glacial drift in the ancestral valleys.

Stop 4. Water tanks, east edge of campus in Newman Arboretum

From this stop at the 970 ft contour, the continued late-glacial and postglacial evolution of Fall Creek valley is easily viewed. The water tanks are on the highest point of the campus, below the water level on a fan-delta that Fall Creek built into glacial Lake Ithaca. A soil pit in the vicinity show a sandy loam, probably subaqueous. Other slightly higher parts of the surface to the east may be underlain by subaerial topset beds. Broad, shallow channels radiate down the delta slope from the apex.

Far on the southwestern skyline is a notch which is said to have puzzled Professor R.S. Tarr and others since. Is it a windgap recording the ancestral course of Fall Creek to the southwest, prior to capture by a north-draining escarpment stream? In part it is an optical illusion formed by a low ridge profiled against adjacent higher hills, but the location is intriguing.

Northeast of the water tanks is the Newman Arboretum, being developed as a major regional collection of native trees and shrubs. The Arboretum crosses the slopes of an abandoned meander of Fall Creek with a floor at about 900 feet, the regional level of glacial Lake Newberry. Lake Newberry drained past the south end of Seneca Lake toward Elmira, and was a very extensive ice-marginal lake across central New York. A smaller meander terrace 30 ft lower, in the shrub collection and test garden area, still shows an abandoned meander channel at its outer bend. This lower meander scar must be very close to a bedrock floor.

Stop 5. Flat Rock

This section of Fall Creek, slightly eroded into shale and siltstone, is the local and temporary base level for upper Fall Creek valley. No bedrock is now exposed in the stream bed until north of Maclean, a distance of at least 10 miles. In reexcavating its interglacial valley Fall Creek here encountered a bedrock spur and became superposed across it, thus greatly deterring further downcutting and permitting the broad lateral swings of the meander belt upstream. This popular local swimming hole was almost obliterated by a nasty overnight rainstorm in late October 1981. Some of the large slabs of siltstone in the stream bed were obsrved to be flipping edge-over-edge during the flood, which reached almost to road level.

Several hundred meters downstream, Fall Creek drops over a low waterfall and loses its bedrock floor, which appears again upstream of the Forest Home Drive bridge at the Wildflower Garden. An ancient buried channel of Fall Creek apparently crosses beneath the modern channel in the interval of no rock exposures.

Stop 6. Mundy Wildflower Garden, Cornell Plantations.

The Mundy Wildflower Garden is established on the floor of Fall Creek valley in another segment of a buried interglacial valley. A short distance downstream from the parking lot, Fall Creek again drops over a low waterfall into a segment a few hundred meters long in which no bedrock is exposed. A low, swampy floodplain in a nearly abandoned meander scar creates a natural habitat for many spring wildflowers. An oxbow swamp is in a well defined channel at the base of the cut bank of the meander scar. The Mundy Wildflower Garden is flooded by extreme high water, but the flora seems to thrive on the aperiodic disturbances.

Stop 7. The "Forest Home runaround" and Beebe Lake.

A gravel-floored abandoned meander followed by Plantations Road sweeps cleanly around a meander core (or Umlaufberg) on which the Cornell Plantations headquarters building and the rhododendron garden are located. Where Plantations Road and the "runaround " intersect Forest Home Drive along Beebe Lake, no bedrock is exposed. Beebe Lake, like several valley segments immediately upstream, is in a segment of an interglacial valley with a floor below the modern channel of Fall Creek. At the stone bridge over the upstream end of Beebe Lake, the rock walls of the buried valley are exposed, as they also are at the dam. In between is a buried valley of uncertain depth and trend.

Stop 8. Mount Pleasant

The accordant summits of the Appalachians are a subject long familiar to geomorphologists. In the gentle foreland fold belt of the Ithaca region, structure is not an important factor in summit height. Mount Pleasant is a cuestaform ridge held up by thicker-bedded sandstone and siltstone units in the Upper Devonian section. The plateau to the north, including the subsequent valley of Fall Creek at the base of the north-facing escarpment face, ranges in altitude from 1000-1400 feet and is underlain by more erodible shale formations. As the regional topographic slope is to the north and the strata dip south, there is considerable truncation of strata by the upland surfaces (Fridley, 1929, p. 116).

Fridley correlated the upland around Ithaca with the Schooley Peneplain of Pennsylvania, generally found in central New York at an altitude of 1600-1700 feet. He supposed that the somewhat higher hills trending northeast-southwest just south of Ithaca were not controlled by more resistant bedrock, but were along the preglacial divide between the St. Lawrence and Susquehanna drainages. Of course, the concept would imply that headward erosion and capture by a north-flowing stream has progressed as far south as the Ithaca region in preglacial time.

Mount Pleasant and its westward extension known locally as Turkey Hill have been segmented into north-south elongate elliptical ridges by glacial erosion and perhaps meltwater overflow. An especially clear example is a small gully that originates on the north face of Mount Pleasant one mile west of the observatory and drains south into Ellis Hollow across the trend of the ridge crest. No catchment area is available for this gully to erode such a channel, but if it collected meltwater from an ice margin that briefly rested against the north face of Mount Pleasant in late-glacial time, an adequate flow would have been available to cut such a channel in the few centuries that were available for such events.

Stop 9. Belle School Road, Caroline.

The road, here just below 980 feet, forms the divide between the St. Lawrence and Susquehanna drainage. This is the floor of the meltwater channel that was the outlet of glacial Lake Ithaca. To the south, the gradient averages about 10 ft/mi in the 18 miles to the Susquehanna River at Owego. To the north, however, Sixmile Creek drops 600 feet in about 8 miles to Cayuga lake, a gradient of 75 ft/mi. The regional asymmetry of stream gradients is not obvious at Belle School Road, however; swamps drain in both directions from the flat valley floor.

This is probably the valley that was described by R.S. Tarr at the 1905 meeting of the Geological Society of America, when in complimenting Tarr for his perceptive analysis, W.M. Davis proposed that such valleys should be called "through valleys" (Tarr, 1905). Meltwater overflow from proglacial lakes on the north sides of the divides undoubtably helped erode these valleys, since lakes formed both during the advance and retreat of each ice margin that crossed the region.

Most of the highest hills of the region lie within a few miles north or south of the present divide. In the valleys, the acute junction angles of tributaries point north on the north side of the divide and south on the south side. Even though the summits have been rounded and somewhat lowered by ice erosion, the valleys have been widened and lowered, and the former valley side spurs have been trimmed back, both summit heights and tributary junction angles suggest that the present divide is not far from its preglacial position. It is a little surprising that the nearly 10-fold gradient advantage of the north-flowing drainage, that must have been established by mid-Pleistocene time, has not yet begun to shift the divide toward the south from this point. The two tributaries that drain down the west valley wall from Durfee Hill cross the western kame terrace only a few hundred meters apart, and their alluvial plains are separated only by Belle School Road. In any local storm either one could divert and be captured by the other.

Stop 10. (optional). King Road Overlook (1300 feet)

The view north over the Cayuga trough and Ithaca provides an excellent review of the regional geomorphology.

Stop 11. Upper Robert H. Treman State park (Enfield Glen)

The final stop of the trip is in Upper Treman Park, where Enfield Creek has reexcavated an interglacial valley to a point a short distance downhill from the parking lot. There, the postglacial stream became superposed on a bedrock spur and has intrenched along vertical joints to a depth of at least 120 feet above Lucifer Falls and more than 300 feet below the falls, before it submerges in its interglacial valley. The westward retreat of Lucifer Falls has left at least one former tributary hanging on the high south wall of the gorge. The interglacial valley goes through glacial drift on the hillside just north of the gorge entrance, and is marked by a zone of active seepage, soil creep, and tree throw on both its upstream and downstream face.

The large size of the valley below Lucifer Falls suggests that this valley, like the valleys of Taughannock Creek, Fall Creek, Six Mile Creek, and perhaps others, may have been repeatedly excavated and back-filled with glacial drift during the numerous ice ages of the Quaternary Period.

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ROAD LOG

CUMULATIVE MILEAGE	MILES FROM LAST POINT	ROUTE DESCRIPTION
0.0	0.0	Start, Snee Hall, Cornell University. Exit right on College Ave.
0.2	0.2	Turn right on Campus Road, continue straight ahead past traffic booth on Garden Ave.
0.6	0.4	Turn right on Tower Road. Ascending a series of hanging deltas through the campus.
1.1	0.7	Turn left on Judd Falls Road.
1.5	0.4	Turn right on Forest Home Drive, over bridge and bear right.
1.7	0.2	Turn left up Warren Road.
2.8	1.1	Turn right on Hanshaw Road.
3.2	0.4	Turn right on unpaved Bluegrass Lane.
3.4	0.2	STOP 1 at vegetable gardens.
3.6	0.2	Return to Warren Road, turn right. Note subdued ground moraine topography.
4.1	0.5	Turn right on Freese Road.
4.3	0.2	Turn left into driveway of Dyce Laboratory (Honey Bee Studies); continue straight on Farm Road.
4.5	0.2	STOP 2 in woods above Varna high bank.
4.6	0.1	Return to Freese Road, turn left.

5.5	0.9	Cross Fall Creek. Bridge and bank repairs postdate 1972 and 1981 floods.
5.6	0.1	Turn left on State Route 366 in Varna.
5.7	0.1	Turn left at fire hydrant down farm road in Cornell experimental fields. Follow best gravel road to north across the fields.
5.9	0.2	Down scarp of upper terrace.
6.2	0.3	Turn right on gravel road.
6.3	0.1	Turn left along forest edge.
6.4	0.1	STOP 3 at base of the "Varna Moraine" (actually an alluvial terrace scarp). Walk north through the woods to the bank of Fall Creek.
7.1	0.7	Return to State Route 366, turn right.
7.7	0.6	Turn right on Forest Home Drive. Flood of 1981 exposed bedrock in channel, here.
8.5	0.8	Turn left into Cornell Plantations, follow one-way signs to right.
8.7	0.2	Turn right, <u>twice</u>, up Plantations Road.
8.9	0.2	Turn left on Arboretum Drive.
9.1	0.2	STOP 4 at Cornell water tanks.
9.3	0.2	View east of Mt. Pleasant cuesta.
9.7	0.4	View southwest from Newman overlook: windgap of ancestral Fall Creek?
10.3	0.6	STOP 5. "Flat Rock"; Fall Creek at Plantations entrance.
10.8	0.5	Continue downstream on Forest Home Drive to stop sign at Caldwell Road. Go straight ahead into parking lot of Mundy Wildflower Garden. STOP 6 in Wildflower Garden.
10.9	0.1	Exit right from parking lot onto Caldwell Road. Turn right on Plantations Road through the underpass around an abandoned meander to Beebe Lake.
11.5	0.6	Turn right on Forest Home Drive.

11.6	0.1	STOP 7: intersection of McIntyre Place and Forest Home Drive. Walk to stone bridge at head of Beebe Lake.
11.7	0.1	Up McIntyre Place to Judd Falls Road. Turn right.
12.0	0.3	Turn right on Tower Road.
12.7	0.7	Turn left on Garden Ave, continue downhill past traffic booth to College Ave.
13.1	0.4	Turn left on College Avenue.
13.3	0.2	Turn left into Snee Hall parking lot. LUNCH STOP. (End of Sunday excursion.)
0.0	0.0	Start, Snee Hall, Cornell University. Exit right on College Avenue.
0.2	0.2	Turn right on Campus Road.
0.4	0.2	Turn right at traffic booth on Campus Road.
0.7	0.3	Traffic light. Continue straight ahead (east) on State Route 366.
2.0	1.3	View ahead of Mt. Pleasant, Ellis Hollow to the southeast.
4.6	2.6	Turn right up Baker Hill Road. Good views to north during ascent.
5.2	0.6	Small bench on hillside. Drainage on west side of road is to the south, through the ridge crest.
5.7	0.5	Turn left on Mt. Pleasant Road (unpaved).
6.6	0.9	STOP 8. Observatory, radio towers.
7.5	0.9	Return west on Mt. Pleasant Road onto paving straight ahead past Baker Hill Road.
7.7	0.2	Small gully noted at mileage 5.2 passes under road. Probable meltwater valley.
8.5	0.8	Views north and west from near Deer Haven Drive.
9.0	0.5	Turn left on Turkey Hill Road. Views southwest of Ithaca College. Upper row of college buildings are on an ice-marginal overflow channel at 1040 ft. above sea level.
9.7	0.7	Cross Cascadilla Creek. Old records described a well 100 feet deep that did not reach bedrock in the valley floor near here (Tarr, 1909a, p. 20).

10.6	0.9	Turn left on Ellis Hollow Road. Across the road is the main quarry of the Finger Lakes Stone Co., from which many Cornell Unviersity buildings have been faced with "Llenroc".
12.6	2.0	Bear right onto Thomas Road.
13.6	1.0	Good view to left of the 1060 ft. meltwater channel that controlled Freeville-Dryden Lake.
14,4	0.8	Beaver pond in south-draining floor of meltwater channel.
15.0	0.6	Cross State Route 79 at Caroline. Continue straight ahead on Lounsberry Road (County Route 113). Road follows radial slope of the large Brooktondale delta/fan.
16.1	1.1	Cross State Route 330. Continue ahead up White Church Road onto delta/fan top.
16.6	0.5	Turn left and continue south on White Church Road. Cross major distributary channel in church camp. Continue south on kame terrace with colluvial cover from steep hillside.
18.6	0.3	STOP 9 on St. Lawrence - Susquehanna divide.
19.1	0.5	Continue west on Belle School Road to Coddington Road. Turn right on Coddington Road. Drive north along kame terrace.
20.4	1.3	Turn left on Miller Road, up Steventown Hill.
22.3	0.5	Turn right on Nelson Road.
24.1	1.8	Turn right on Troy Road.
25.3	1.2	Turn left on King Road.
25.6	0.6	STOP 10. Cayuga Valley overlook.
26.6	1.0	Turn right on State Route 96B (Danby Road).
27.1	0.5	View of Cayuga trough and Cornell Campus. Note convex valley walls.
28.7	1.6	Turn left on Clinton Street (96B).
29.5	0.8	Turn left on Meadow Street (Rt. 34-13).
30.1	0.6	Stop light. Continue south on Elmira Road (Rt. 34-13).

31.2	1.1	Entrance to Buttermilk State Park. View of Buttermilk Falls.
31.7	0.5	Railroad overpass and junction with Floral Avenue. Note hanging deltas of Coy Glen to right rear.
32.7	1.0	Turn right on State Route 327 to Treman State Park.
33.1	0.4	Continue to right on State Route 327 past lower park entrance.
33.6	0.5	Abandoned gravel pit in hanging delta. Excellent hanging-delta morphology uphill for next half mile.
35.7	2.1	Turn left into upper entrance of Robert H. Treman State Park.
36.6	0.9	STOP 11. Upper Enfield Glen. Walk downstream into gorge to base of Lucifer Falls. Cross footbridge, return to parking lot via South Rim trail.