Finger Lakes Gorges Revisited

Peter L.K. Knuepfer
Tim K. Lowenstein
Department of Geological Sciences and Environmental Studies
Binghamton University
Binghamton, NY 13902-6000
email: knuepfr@binghamton.edu
email: lowenst@binghamton.edu

Introduction

The Finger Lakes region of central New York is justifiably world-renowned for its beauty, especially the spectacular deep gorges–the Finger Lakes glens--that characterize tributary streams draining into the central troughs. The origin of the troughs themselves has been the source of debate for as long as geologists have ventured into upstate New York (as summarized by Mullins and others, 1989). The recent geophysical studies by Mullins and his colleagues (Mullins and Eyles, 1996) have resolved much of this controversy, demonstrating that the modern troughs, at least, must have been formed by a combination of glacial scouring and the action of high-pressure sub-glacial meltwater. Seismic stratigraphic relationships suggest that the stratigraphic and morphologic record left behind by this event–including the Valley Heads Moraines (VHM) as well as much of the infill of the Finger Lakes troughs themselves--must have occurred between (and including) VHM time, around 14.9-14.4 ka ^{14}C yr. B.P. (Muller and Calkin, 1993). Late-stage trough-fill sediments were deposited until 13.6 ka ^{14}C yr. B.P. (Wellner and others, 1996), by which time ice had retreated north of the modern Finger Lakes. Our goals on this field trip (Figure 1) are to consider the implications of this record for development of the modern Finger Lakes glens/gorges.

Late-Glacial Evolution of the Finger Lakes Troughs

The spectacular reflection data obtained by Mullins and Hinchey (1989) and discussed in more detail in Mullins and Eyles (1996) have provided a fundamentally

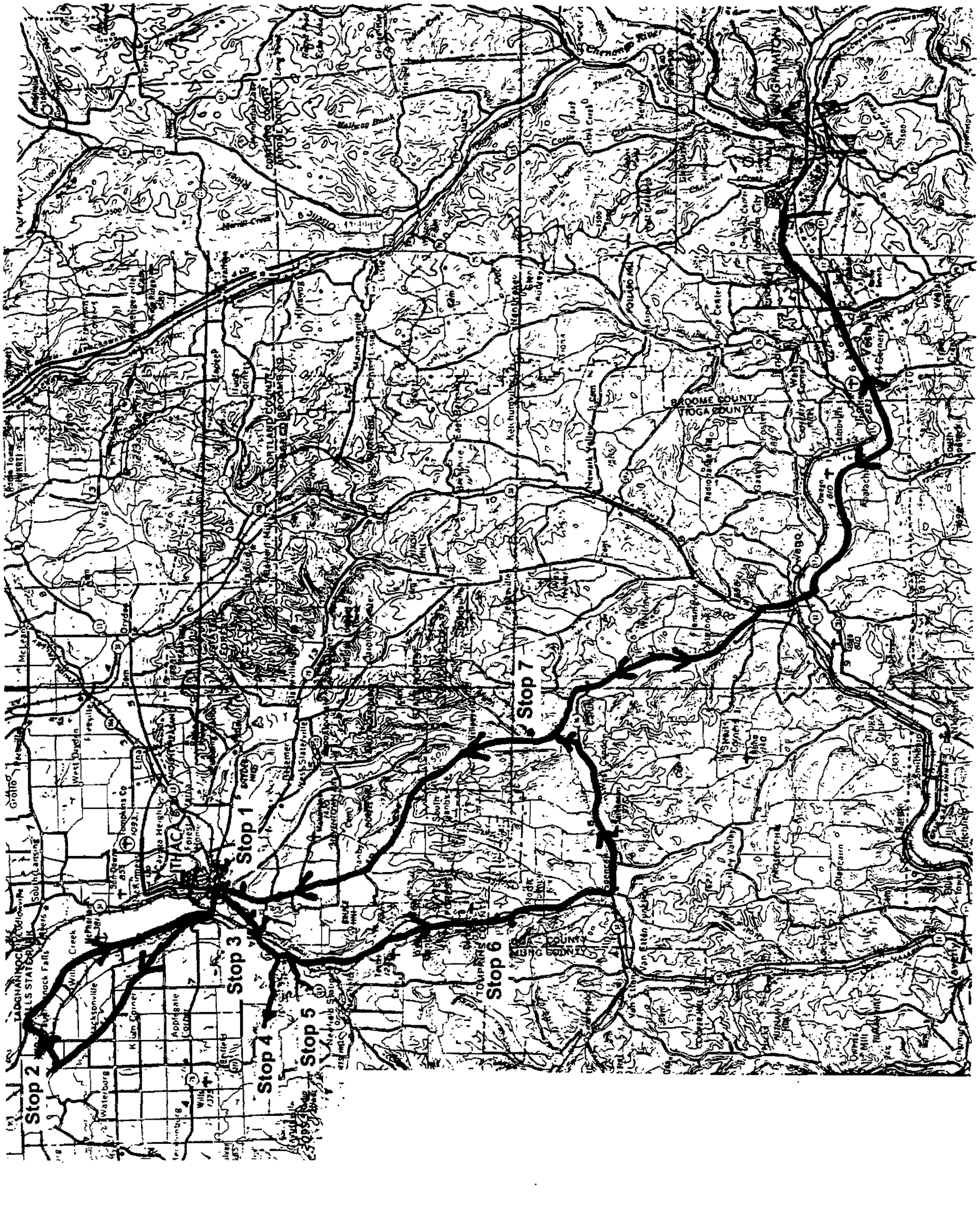


Figure 1. Map showing field trip stops. Base from U.S. Geological Survey 1:250,000 Elmira and Binghamton sheets.

new view on the formation of the Finger Lakes troughs. While an ice-erosion origin for the troughs had long been recognized (Mullins and others, 1989), it wasn't until extensive seismic reflection studies had penetrated the sub-lake stratigraphy that the full nature of sub-glacial erosion could be recognized. We summarize here what we consider to be the most important observations and conclusions of this work, at least as related to our goal of understanding the evolution of the Finger Lakes gorges.

(1) Deep bedrock scour below each of the Finger Lakes is as great as 306 m below sea level (Seneca Lake). The depth of scour, coupled with seismic stratigraphy of the deepest sediments that fill these basins, is most consistent with erosion by high-energy, high-pressure sub-glacial meltwater (Mullins and Hinchey, 1989; Mullins and others, 1996). It is, perhaps, no coincidence that this interpretation is consistent with the argument by Shaw and Gilbert (1990) that subglacial meltwater flood(s) played a major role in development of the drumlin field of the Ontario lowland to the north. Mullins and Hinchey (1989) suggest that the VHM were deposited by the water from this scour event; we'll stop at a large exposure of VHM sediment that will provide an opportunity to discuss this hypothesis.

(2) The oldest sediments preserved in any of the Finger Lakes troughs correlate with and onlap sediment preserved in the Valley Heads Moraines deposits. Assuming synchroneity of the VHM deposits, the best estimate of the age of this event is supplied from the Nichols Brook site in western New York. Muller and Calkin (1993) conclude that ice retreat at this site had begun by 14.4 ka ^{14}C yr. B.P., with radiocarbon dates as old as 14.9 ka ^{14}C yr. B.P. obtained from this site.

(3) Sub-glacial scour apparently removed any pre-existing sediment within the bottoms of the troughs, although some sediment of likely last interglacial age is preserved locally within or near hanging valleys on the margins of troughs. The principal site that has been well studied is the "Fernbank" exposure on the west margin of Cayuga Lake (Maury, 1908; Bloom, 1972; Karrow and others, 1990). Interglacial deposits, assumed to be of Sangamon age, were reported from this location, providing

direct evidence that a Cayuga Lake trough of some sort existed prior to Wisconsin glaciation (Bloom, 1972, 1986). The lack of interglacial sediment as interpreted from seismic stratigraphy from the Cayuga Lake trough proper indicates that the present depth of excavation of the trough is a late-glacial feature.

(4) Sedimentation in the troughs was substantial in late-glacial time, up to 270 m total (Mullins and others, 1996). The bulk of this sedimentation occurred under proglacial lake conditions while ice was retreating northward in the troughs. The deposition initially was largely from the north, consistent with subaqueous outwash (Mullins and others, 1996). A reversal in direction of inwash into the proglacial lakes occurred around 13.9 ka ^{14}C yr. B.P., which Mullins and others (1996) interpret as an indicator of substantial lake-level drop. Perhaps this marks the time of retreat of the ice margin into the Ontario lowlands, although Mullins and others (1996) infer that a sedimentation event immediately prior to this reversal represents deposition from an ice margin that terminated at the north end of the present Finger Lakes. In any event, Mullins and others (1996) indicate that sedimentation in the period 13.9 ka ^{14}C yr. B.P. to 13.6 ka ^{14}C yr. B.P. consisted predominantly of sand and gravel deposits from lateral and southern sources, marking the first significant influx of sediment from these sources into the troughs. Alternatively, one could interpret the available evidence to indicate that prior to 13.9 ka ^{14}C yr. B.P. debris influx from the southern and lateral drainage systems was relatively minimal; we consider this interpretation below. There need not have been a regional change in the influx from lateral tributaries. However, boreholes south of both Canandaigua Lake and Cayuga Lake record the burial of lacustrine sediments by sand and gravel at this time, indicating a lake level comparable to the modern and progradation of deposition from the south. Thus, the lowering of lake level must have been complete by this time.

(5) Post-glacial infill of the lake troughs is relatively minor. Maximum interpreted thickness of post-glacial lake sediments (their Sequence VI) in Cayuga Lake is only about 12 m (Mullins and others, 1996) to perhaps greater than 15 m (Mullins, 1998).

Thus, the modern Finger Lakes troughs, including Cayuga Lake, owe their present morphology and sedimentation to late-glacial and post-glacial processes. However, these interpretations do not bear on the issue of the ultimate origin of the Finger Lakes, failing to address whether the troughs existed prior to the late Wisconsin ice advance. The stratigraphic relationships place strong constraints on evolution of the modern landscape, but to understand something of the broader context of trough development we turn our attention to the gorges themselves and the record they preserve. We will focus our attention on Cayuga Lake and its gorges, the focus of this field trip, as this area has been most intensively studied.

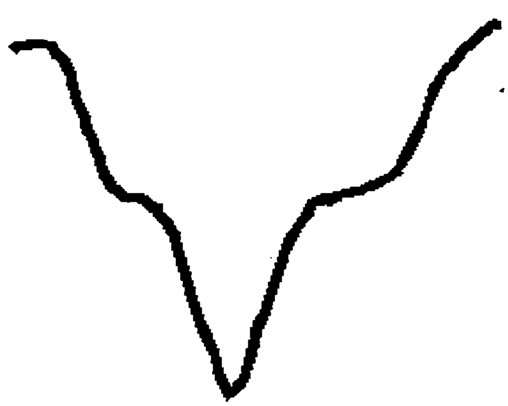
Prior Studies of Finger Lakes Gorges–Interglacial and/or Post-glacial?

Early workers (e.g. Matson, 1904; Tarr, 1904) recognized that post-glacial erosion must be invoked to explain the present deep gorges of the Cayuga Lake basin, incised to a base level controlled by the modern lake level. Fairchild (1899) provided a key framework for this interpretation by mapping the extent of pro-glacial lakes in the Cayuga trough. Progressive northward retreat of the Laurentide ice sheet opened progressively lower outlets for lake overflow (such as Grasso, 1970, and Hand, 1978, have described in detail for the Onondaga Valley lakes in the Syracuse area). This produced a series of distinct lake levels, progressively lower, into which tributaries built deltas (e.g., Fairchild, 1934). Most tributaries preserve morphologic and stratigraphic evidence of these pro-glacial lake deltas. Available exposures into these surfaces that we have visited in the Cayuga Lake trough generally display foreset beds, in some cases overlain by topset beds or even till (e.g. Stops 2C and 5 on this trip). As many as 7 or more delta surfaces are preserved above some of the gorges (Figure 2).

The early observers (e.g. Matson, 1904; Rich and Filmer, 1915) noted that the modern gorges generally are incised into broader valley bottoms, producing in some cases a valley-in-valley morphology (Figure 3). Rich and Filmer (1915) argued that multiple glacial events must have occurred to produce this landscape. They reasoned that tributary valleys evolved (widened) during interglacial times, and were buried by

Figure 2. Diagrammatic sketch of the Ithaca region looking south. From Morisawa, 1950.

drift when ice covered the landscape. The main north-south Cayuga trough was deepened during each glacial period, and glacial retreat was followed by incision of now-hanging valleys to the newly established base level. Thus, they argued that the overall valley form of the upland valleys is inherited from pre-latest glacial (interglacial?) times, with post-glacial incision forming the modern gorges. The "classic" example cited in their work is the valley of Six Mile Creek. Von Engeln (1929) interpreted weathered gravels below till as evidence for deposition during advance of the last glacial maximum. Muller (1957) essentially confirmed this interpretation by dating wood in proglacial lake sediments at greater than 35,000 years. Subsequent dating of this and other sites in Six Mile Creek indicate that a proglacial lake, presumably impounded by the advancing Laurentide ice sheet, occupied a pre-existing valley at 41,900 ^{14}C yr. B.P. (Bloom, 1972).



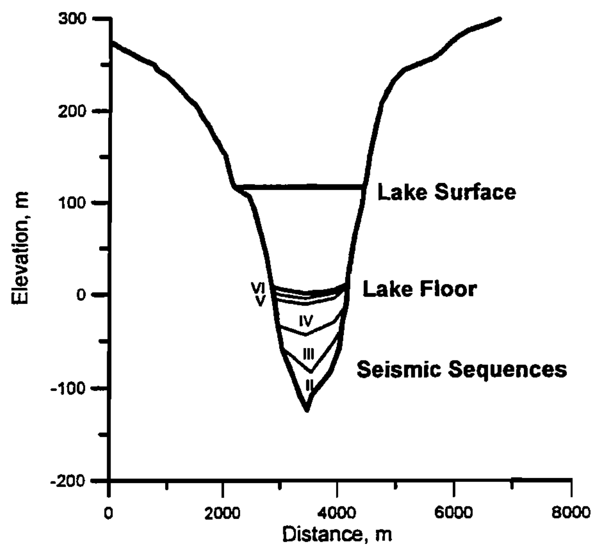


Figure 3. "Valley-in-valley" profiles. Left profile is typical of those found in rapidly incising valleys in the eastern Central Range of Taiwan (e.g., Willemin, 1993) and shows a canyon incised into a broader, higher valley below drainage divides. Not to scale. Right profile shows the shape of the Cayuga Lake trough as obtained from the Ludlowville 7.5' topographic map with sub-lake morphology and seismic stratigraphy generalized from Mullins and Hinchey, 1989. The bedrock incision below the lake floor is not as dramatic an example of "valley-in-valley" as the tectonically induced incision in Taiwan, but the overall character of valley incision is similar.

The morphology of Enfield Glen and other gorges also is cited as evidence for interglacial (or at least pre-latest glacial) development of tributary gorges. The relatively broad, open upper and middle portions of Enfield Glen have been described elsewhere (e.g. Cornell University, Dept. of Geology, 1959) as being re-excavated sections of an interglacial valley (Figure 4). Although this is a reasonable morphologic argument, we have been unable to find exposures of pre-latest glacial deposits to confirm this.

The available evidence and interpretations provide a convincing argument that the Finger Lakes gorges have a complex history, and that tributary gorges (or at least valleys) existed prior to the LGM. The modern gorges clearly are a post-glacial feature. But how and why did excavation occur, and how long has it taken to excavate (and preserve) this spectacular landscape?

Implications of Recent Work

The sites of the modern gorges were covered by ice when Valley Heads Moraine deposition was occurring at 14.9-14.4 ka ^{14}C yr. B.P. Upon ice retreat from the Valley Heads position, ice dammed meltwater escape to the north, the VHM deposits limited meltwater escape to the south, and local divides and cols controlled meltwater escape to the east and west. Thus, a series of proglacial lakes was impounded (Fairchild, 1934), with local streams (such as Enfield Creek) forming deltas into these lakes (Figure 5). As the ice retreated north, lake levels dropped, and delta positions dropped and advanced valleyward (Figure 5). Cayuga Lake and other Finger Lakes had apparently reached levels close to modern by 13.6 ka ^{14}C yr. B.P. Thus, base-level fall that triggered lowered deltas and tributary valley incision must have occurred within about no more than 1300 years. Indeed, Mullins and others (1996) imply that gorge incision was accomplished only after sedimentation from lateral and southern sources is recorded in the Finger Lakes cores and seismic records, i.e. in the interval 13.9-13.6 ka ^{14}C yr. B.P. This seems unlikely; other seismic stratigraphic evidence indicates a largely ice-free Cayuga Lake trough by 13.9 ka ^{14}C yr. B.P. (Mullins and others, 1996), which means lake levels already would have lowered in response to ice retreat.

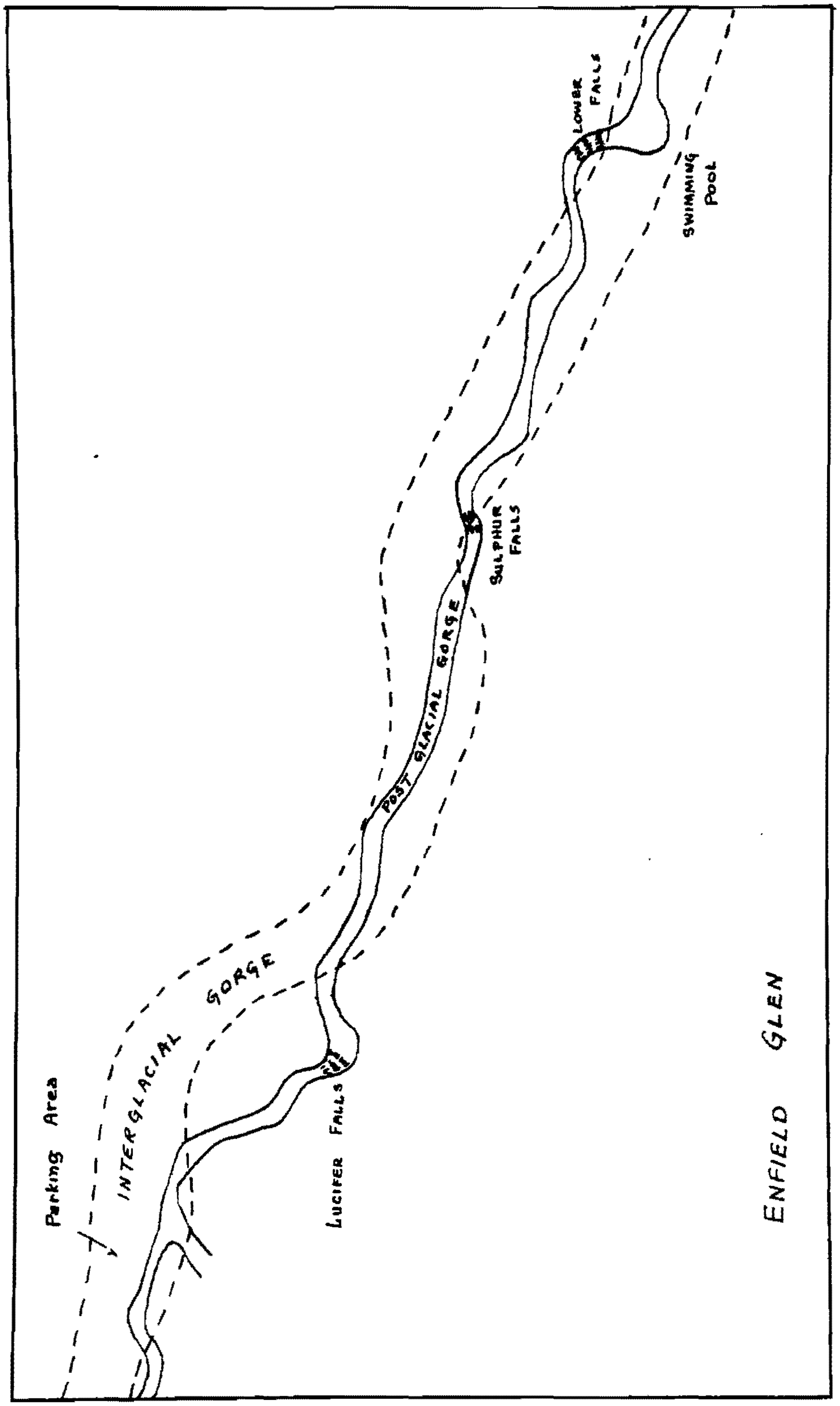


Figure 4. Inferred interglacial gorge of Enfield Creek, Enfield Glen, Robert Treman State Park. Similar figures are published in many guidebooks; this version is by Morisawa, 1950.

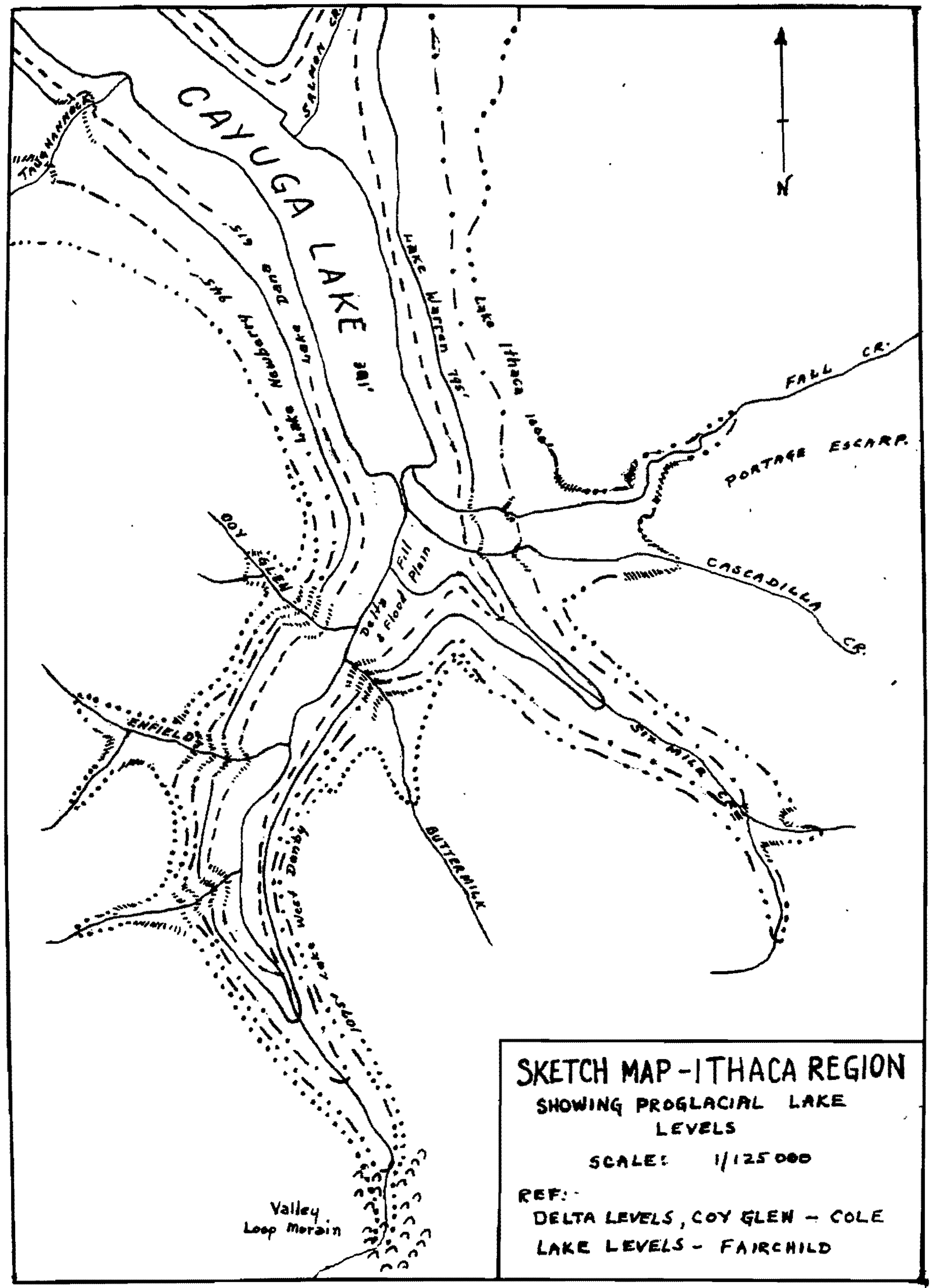


Figure 5. Proglacial lake levels and approximate delta distributions in the Ithaca region. From Morisawa, 1950.

Regardless of how short the time period was, formation of the deltas of the Finger Lakes, and at least some significant incision, was accomplished within a very brief interval of late-glacial time.

The implications of these dates are extremely important for understanding modern geomorphic processes and evolution of the Finger Lakes gorges. The base-level fall that produced the potential for gorge incision was rapid, but occurred in stages. Each drop in lake level was accompanied by trough-ward migration of the delta front and drop in level. Each change in delta level, then, must have been accompanied by formation of a knickpoint within the tributary channel, where the creek dropped from a previously established delta level to the new level. The final drop formed the modern prograding delta level for streams such as Taughannock Creek that drain directly into the lake. Streams like Buttermilk Creek that drain into southern inlet channels (in this case, Cayuga Inlet) actually have undergone minor post-glacial base-level *rise* as progradation of the inlet channel deposits has altered local base level.

The key point here is that knickpoint development is intricately tied into base-level fall, and the potential height (and, to some extent, position) of waterfalls was established during the late-glacial base-level drop. In this context, it is worth noting that incision and knickpoint retreat in individual streams have occurred very differently in response to this common base-level drop. The main waterfalls at Buttermilk Creek have retreated little from their positions established at and near the gorge mouth, whereas retreat of Taughannock Falls appears to be far more substantial (Figure 6). It is beyond our current purpose to speculate about the factors that have controlled this differential retreat.

Finally, we argue that the bulk of geomorphic work–base-level drop and subsequent knickpoint development and retreat–must have been substantially accomplished contemporaneously with initiation of the modern gorges during lake-level lowering. This clearly must be the case in streams such as Buttermilk Creek and Falls Creek, where the main knickpoint has not retreated significantly. For many of these

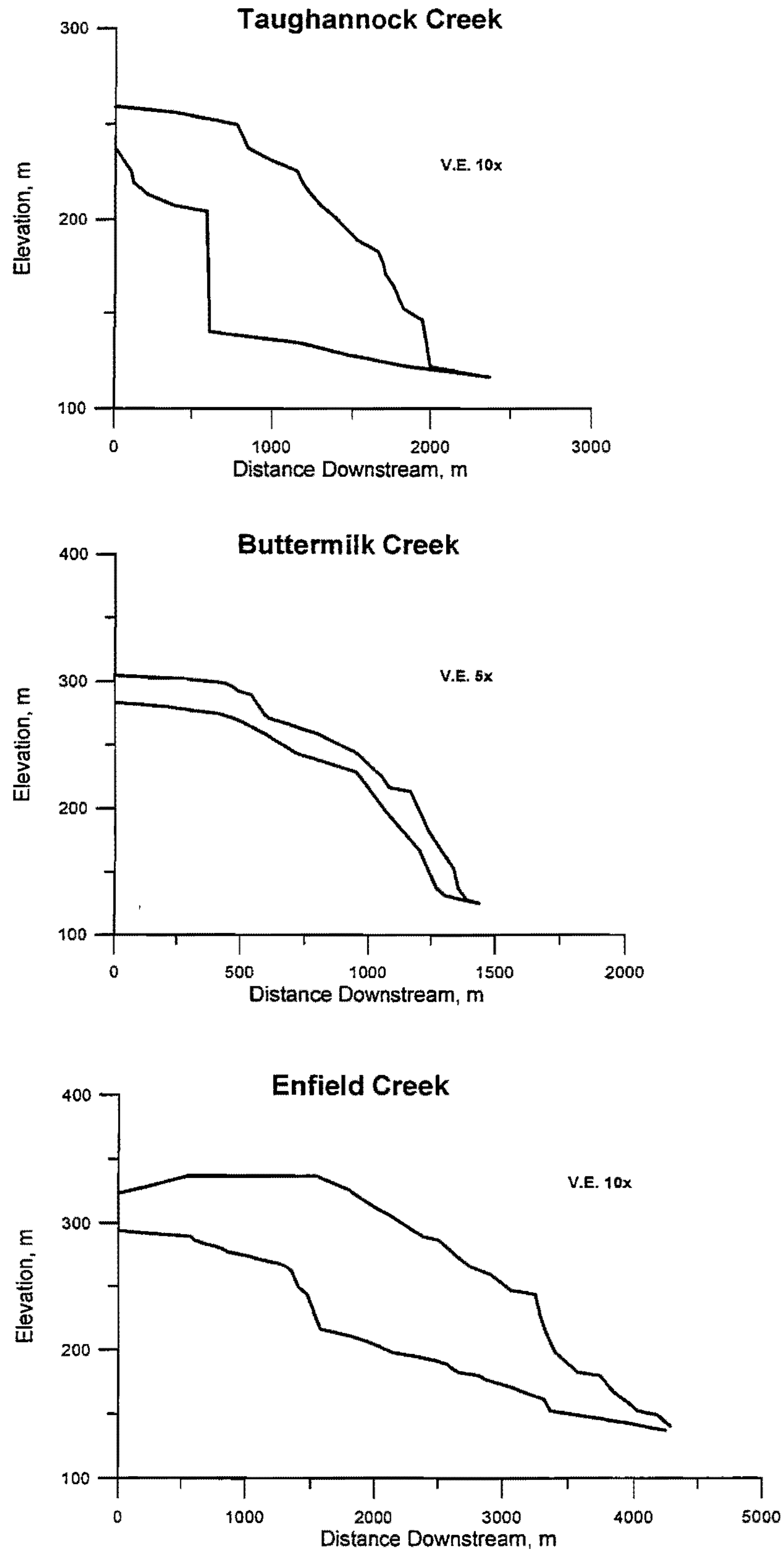


Figure 6. Long profiles of creek (lower line) and gorge crest (upper line), Enfield and Buttermilk Creeks from Ithaca West 7.5' topographic map, and Taughannock Creek from Ludlowville 7.5' topographic map. Note differences in degree of stream incision, distribution of incision, and preservation of delta sufaces.

streams, then, the discharge during late-glacial time must have been substantially more efficient in producing erosion than has been the case through the Holocene. We speculate that there was little vegetative cover on hilltops during the latest Pleistocene glacial retreat. Direct paleoclimatic data are lacking from this area, but pollen studies from other areas in the Northeast (esp. Wallface Pond in the Adirondacks–Whitehead and Jackson, 1990–and Tannersville Bog in the Poconos–summarized by Gaudreau and Webb, 1985) indicate that vegetation conditions during and immediately after ice retreat were comparable to modern tundra environments, although scattered spruce probably was present. This lack of vegetation, coupled with the lack of soils on freshly deglaciated uplands, likely would have resulted in high runoff/infiltration ratios and more effective discharge in upland basins. These may well have been the key conditions for rapid incision of streams tributary to the Cayuga Lake trough and other Finger Lakes basins.

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Road Log

Cumulative Mileage	Miles from Last Point	Route Description
0.0	0.0	Start at Lot C, Anderson Center, Binghamton University campus. Exit north and turn left onto Vestal Parkway, then immediately right onto Hwy. 201. Continue north on Hwy. 201 through the Johnson City traffic circle and exit west onto Hwy. 17. Travel west on Hwy. 17 to Owego.
20.8	20.8	Exit onto Hwy. 96 north through Owego to Candor, NY.
31.8	11.0	Continue directly north on Hwy. 96B toward Ithaca.
49.4	17.6	View area on left overlooking Cayuga Lake trough. Recent construction has impaired the view of geologic features.
50.1	0.5	Turn right onto Ithaca College campus and right toward football stadium.
		STOP 1. Overview. The Ithaca College campus is built on hanging deltas of Six Mile Creek and commands a spectacular view of the Cayuga Lake basin. Features that can be seen on a clear day include the oversteepened margins of Cayuga Lake trough to the north and hanging deltas of Coy Glen and Enfield Glen to the west and southwest. Similar hanging deltas characterize most of the streams that drain into the Finger Lakes troughs and the filled troughs to the south of the lakes. This stop affords us the opportunity to set the stage for features to be observed and discussed during the remainder of the trip.
50.3	0.2	Retrace steps to Hwy. 96B.
50.5	0.2	Turn right (north) on Hwy. 96B and descend South Hill into Ithaca. Continue on Hwy. 96B to its junction with Hwy. 13.
52.0	1.5	Junction Hwy. 13 north, Meadow St. in Ithaca. Turn right.
52.3	0.3	Turn left on Hwy. 96 to the "octopus" and continue up the hill past the Paleontological Research Institute and Thompkins County Hospital, through Jacksonville, and nearly to Trumansburg.
61.9	9.6	Turn right on Taughannock Park Rd. Note increasing incision of Taughannock Creek as we drive downstream. Note also our position on a relatively flat surface, one of the highest hanging deltas of Taughannock Creek.
63.1	1.2	Junction with Falls Rd.; turn right and cross bridge.
63.2	0.1	Turn into parking lot on left.
		STOP 2A. Upper Taughannock Falls. We walk onto the old rail bridge above (upstream of) Taughannock Falls. Although incision of Taughannock Creek has been increasing as we drove downstream from Hwy. 96, here is the first significant knickpoint in the channel–a drop of some 15 m.

Cumulative Mileage	Miles from Last Point	Route Description
		The view downstream is instructive: the lake-ward terminus of the high delta on which we have parked is clearly visible about 0.8 km (0.5 mi) downstream. Some of the incised meanders of the gorge upstream of the main Taughannock Falls also are visible.
63.9	0.7	Return to Taughannock Park Rd. and turn right. Stop at Falls Overlook parking area on right.
		STOP 2B. Taughannock Falls Overlook. The view area affords an excellent perspective of the main Taughannock Falls. Here the creek drops some 65 m through late Devonian Genesee Group sediments. The top of the falls is formed in resistant siltstone of the Sherburne member (Grasso and others, 1986); the notch at the lip of the falls has remained little changed since a rockfall in the late 1880s or early 1890s. One question to consider is how much the waterfall has retreated upstream. A possible clue is afforded by the retreat of the amphitheater in which the modern waterfall is located. Another possible clue is the position of the delta front, downstream of this position, that corresponds to the elevation of the crest of the waterfall. Bloom (1972) has suggested that the broad valley downstream of the waterfall is indicative of re-excavation of an interglacial valley. We are unaware of any exposed pre-latest Pleistocene unconsolidated sediments anywhere within the lower gorge. A related issue is how much of the incision we see here has occurred in post-glacial time, and how much may have occurred while the ice was retreating northward through the Cayuga Lake trough (and other Finger Lakes troughs) and providing the dams for progressively lowering lakes (and accompanying deltas).
		STOP 2C. Gravel Quarry. Cross Taughannock Park Rd. from the Falls Overlook parking area and walk onto the unpaved road on the left side of the small parking area. Walk about 100 m into an old quarry. This quarry is cut into the front edge of the most prominent high hanging delta of Taughannock Creek. Recent working of the northeast wall of the quarry has resulted in a spectacular exposure of the delta-front foreset beds. Sediments include well stratified sands and gravels with occasional clayey and silty interbeds.
63.9	0.0	Return to vehicles. Drive down Taughannock Park Rd. to Hwy. 89. Note the small delta surfaces across which we drive. The youngest delta, of course, is the active delta complex on which much of the developed area of Taughannock Falls State Park is located. This is one of the

Cumulative Mileage	Miles from Last Point	Route Description
		largest deltas on Cayuga Lake. If we use the analog from Canandaigua Lake and the evidence that Mullins and others have provided, we can assert that this delta probably began to form in latest glacial time, after base level for Taughannock Creek had dropped to approximately its modern position. Again, we can consider how much of the incision of bedrock occurred during this drop in lake levels, and how much is post-glacial.
64.7	0.8	Junction Hwy. 89. Turn right (south) to Ithaca.
74.2	9.5	Junction Hwy. 13 south in Ithaca. Turn right on Hwy. 13 south.
76.5	2.3	Entrance to Buttermilk Falls State Park on left. Turn in to Buttermilk Falls and park. **STOP 3 (LUNCH). Buttermilk Falls and Buttermilk Glen.** Time permitting, we'll walk up the lower park of Buttermilk Creek. Much of the incision is represented by the two main waterfall in the lower creek; this contrasts sharply with the situation at Taughannock Creek. Delta surfaces are not as well preserved here, but again hanging deltas do occur. Why is there such a difference in incision pattern? Was there no pre-last glacial channel to re-excavate here? Joint systems play a minor role in erosion by Buttermilk Creek, but spectacular potholes are excavated into the rocks at the gorge bottom. We may meet vans at the parking lot above the gorge, or we may continue from the lower entrance to the State Park. The road log assumes the latter.
78.0	1.5	Return to Hwy. 13 and turn left (south). Turn right at Hwy. 327.
81.0	3.0	Drive to upper entrance to Robert Treman State Park and turn left. Note an entrance to an abandoned gravel quarry on the right 0.2 miles before the entrance to the park. This quarry, formerly operated by the Town of Enfield, exposed foreset beds of the uppermost Enfield Glen hanging delta. These beds were overlain by a poorly consolidated, thin (less than 2 m exposed) till. We interpret the deltaic sediments as marking the input of Enfield Creek sediments into the highest level of the pro-glacial Cayuga Trough lake, with a nearby ice margin overriding the sediments during a brief interval of re-advance.
81.75	3.75	Park at entrance to Enfield Glen. **STOP 4. Enfield Glen.** No tour of the Finger Lakes gorges around Ithaca would be complete without a stop to tour the upper part of Enfield Glen. The parking area and picnic ground are in a relatively broad valley containing an

Cumulative Mileage	Miles from Last Point	Route Description
		alluvial floodplain over bedrock. Note that bedrock is exposed in the valley walls and in tributary channels such as Fish Kill just upstream from the mill. Poorly exposed colluvium mantles other slopes of this valley wall. As we walk into Enfield Glen, note the abrupt change to a narrow gorge deeply incised into well jointed bedrock. Here jointing has played a key role in facilitating excavation of bedrock by the stream. We walk down to Lucifer Falls, below which the valley again opens into a much wider, bedrock-walled gorge. The traditional interpretation is that the wide gorge sections indicate reoccupation of a buried interglacial gorge, whereas the bedrock gorge represents post-glacial incision into the Devonian bedrock (e.g. von Engeln, 1961). The reason for post-glacial diversion through a bedrock gorge is assumed to be a mass of Wisconsin glacial sediment choking the interglacial valley, such that Enfield Creek was diverted and flowed across (and incised into) bedrock. Again, to what extent has the incision occurred in post-glacial times (which is what the "conventional" interpretation would imply) and how much occurred during ice retreat up Cayuga Lake trough? If the stream achieved a base level approximately at the modern Cayuga Inlet altitude, then virtually all of the base-level fall that has driven incision occurred during late glacial time. How much knickpoint retreat has occurred? How can we assess this?
85.5	3.75	Return to Hwy. 13. Note delta surfaces as we drive back down the hill.
87.3	1.8	Turn right (south) on Hwy. 13. Continue on Hwy. 13 to Millard Hill Road; Landstrom Gravel Pit on the right. Turn onto Millard Hill Road and into the parking lot of the Landstrom Pit.
		STOP 5. Landstrom Gravel Pit. *Get permission at the office before entering.* This pit is excavated into the lowermost delta of Enfield Creek and represents the last depositional event before Enfield Creek had stabilized at more or less its current base level. Note the similarity of overall stratigraphy to what we viewed at Stop 2C. Here we have a higher clay content and the development of clay balls and climbing ripples (which may or may not be visible on the day of the field trip).
87.3	0.0	Return to vehicles.
87.8	0.5	Drive north on Hwy. 13 to Decker Road, junction Hwy. 34/96 south. Turn onto Hwy. 34/96 toward Spencer. We soon climb into the Valley Heads Moraine complex of West Danby, NY. This is one of the longest and southernmost valley-filling reaches of Valley Heads Moraines in central New York.

Cumulative Mileage	Miles from Last Point	Route Description
96.8	9.0	Pull off to left side of road at entrance to gravel mining operation. **STOP 6. Gravel Pit.** Walk past the gate and down the hill, noticing poorly exposed well rounded gravels on right. Note hummocky morainal topography visible ahead on to the left. Turn right at road at bottom of hill and enter main gravel workings. Here the Valley Heads Moraine is comprised of well rounded, sorted, and weakly stratified sands and gravels. This is typical of VHM deposits in those exposures we have visited in central New York, as well as in exposures discussed by Yang (1992). Clearly water played an active role in abrasion and deposition in this glacial-marginal environment! We'll discuss the implications of this for development of the VHM and its relationship to the Cayuga Lake trough, the hanging deltas, and the exposures we've already seen.
101.7	4.9	Return to vehicles and drive south to Spencer, NY. Turn left onto Hwy. 96 toward Candor. Note asymmetric valley walls. As is typical of valley walls in east-west valleys in the glaciated Appalachian Plateau, the south-facing walls have relatively gentle slopes and the north-facing walls are steep and truncated. Coates (1966) interprets these as till shadows: south-facing walls have thick lodgement till deposits resulting from loss of basal stress as the glacier descended into the valley, whereas the south wall has thinner, compressed till due to high pressure as the south-traveling basal ice "piled up" against the valley.
108.3	6.6	Turn left (north) onto Gridleyville Crossing Road.
109.4	1.1	Turn left (north) onto Hwy. 96B.
110.2	0.8	Turn right into Robinson's quarry. Note that you shouldn't enter here without permission. The pit managers request that all visiting geologists wear hard hats **STOP 7. Robinson's Gravel Pit.** *Get permission at office before entering pit.* As a final stop, we look at deltaic deposits <u>not</u> associated with the pro-glacial lakes of the Cayuga trough. Here we are downstream of the Valley Heads Moraine of Willseyville Creek. The landform is a kame surface, and we interpret the sediments as primarily deltaic foreset beds. However, they dip back toward the valley wall rather than toward the valley center, suggesting a complex mode of origin. Local slump features and contorted bedding attest to the kame origin of this deposit.
146.1	35.9	Return to vehicles. Drive south on Hwy. 96B back through Candor and on Hwy. 96 south through Owego. Turn east on Hwy. 17 and retrace steps to Binghamton University.