GEOLOGY OF THE ZOAR VALLEY GORGE OF CATTARAUGUS CREEK
CATTARAUGUS AND ERIE COUNTIES, NEW YORK

by

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Abstract

The Zoar Valley Gorge of Cattaraugus Creek cuts west for 7.5 miles through up to 400 feet of Late Devonian shales and siltstones of the Canadaway Formation, part of the Portage Facies of the Catskill Delta. The Laona Siltstone and Shumla Siltstone members of the Canadaway Formation, reported to pinch out west of the gorge, are projected to crop out in the stream bed and in the gorge wall, respectively, where two siltstone units occur. Surface expressions of the Alleghenian Bass Island Trend, reported to occur in the South Branch, a left-bank tributary gorge, are exposed in the main branch as joints and a pop-up fold trending NE. Other joint sets trend N, ENE and NW. The E, ENE and NE features exert significant influence on streambed orientation until cut by a strong NW fracture zone, which then controls streambed orientation. Five instances of continuous strong joint sets bending through 20°-50° of arc occur in the main branch or the South Branch, possible pre-NW tear fault indicators of complex stress distributions. Zoar Valley Gorge incises the bedrock beneath the trace of an ice marginal meltwater channel parallel and adjacent to the Valley Heads Moraine. Subsequent ice recession allowed Cattaraugus Creek to breach the moraine and occupy the pre-glacial Allegheny River Valley in Gowanda, New York. Surficial deposits and landforms provide clues to the sequence of events leading to gorge formation, but present more mysteries. Although flowing parallel to strike, Cattaraugus Creek is not a typical subsequent stream. The stream traverses at least three pre-glacial north-flowing obsequent stream valleys dammed by the Valley Heads Moraine. A curious erosional remnant at the Confluence of the main branch and the South Branch defies explanation. Cattaraugus Creek drops at an average gradient of 0.3% from the head of the gorge to the first rapid, 0.6% from the first rapid to the mouth of the gorge and 0.4% to the end of the rapids one mile downstream of the mouth. Practically all of the drops occur in 19 rapids. A strong correlation exists between rapids, siltstone beds, joints and cross channel cobble and boulder deposits called rock gardens. It is proposed that classic pool and riffle morphology occurs in the bedrock streambed, modified by more resistant siltstone beds and fracture zones. More study is required.

Introduction

"Paper? What paper? It's a raft trip..."

Thus began the collection of observations, ideas, theories, thoughts and random musings presented here on the geology of Zoar Valley Gorge along Cattaraugus Creek, east of Gowanda, New York (Figure 1). Mysteries lurk throughout the stratigraphy, structures, glacial history and geomorphology of the 7.5-mile long, up to 400-foot deep, bedrock gorge. More questions than answers have resulted from this investigation. Whether or not stream flow allows a raft trip or requires a hike, we will have an adventure. Several rapids in the gorge are referenced throughout the paper. Please refer to Figure 2 for their locations.

Stratigraphy (A Classic Floating Section or The Case of the Missing Laona)

Cattaraugus Creek cuts west through Late Devonian (Chautauquan) shales and siltstones of the Canadaway Formation. The Canadaway Formation is included in the Portage Facies of the Catskill Delta (Figures 3 and 4 from Geology of New York, a simplified account, Educational Leaflet No. 28, NYS Museum/Geological Survey 1991). The sediments were eroded from the Acadian Mountains to the east and were deposited along the mid-to-outer shelf, slope and basin edge of a westward deepening inland sea. A series of black shales extending eastward serves as marker beds for time correlations of rapid sea level rises.

Tesmer (1975) states: "The Canadaway Formation in Cattaraugus County contains gray to black shales, various zones of concretions and septaria, and many gray siltstone beds. Black shales are largely confined to the older Dunkirk, South Wales and Gowanda members." Tesmer (1955, pp. 9-10) also includes the Laona, Westfield, Shumla and Northeast Members in the Canadaway Formation. Van Duyne, et al. (1994) interpreted the Laona to be "mid-shelf tempestites deposited during a minor shallowing of the Devonian shale basin."

The original Gowanda type locality occurs along the right bank of Cattaraugus Creek just upstream of Grand Finale Rapid, Gowanda, New York (B4, C4; Gowanda 7½' quadrangle) (Chadwick, 1919, p.157) and Figure 1. Although Pepper and DeWitt (1951) relocates the standard reference section to Walnut Creek, Hanover Township, Chautauqua County, New York (Silver Creek and Forestville 7½' quadrangle), the original type locality fixes the section at the downstream end of Zoar Valley gorge at elevation 750± feet above sea level (asl).

From here, it gets murky.

According to Tesmer (1975), the Gowanda member is 270-280 feet thick. The Corell's Point Goniatite Bed, corresponding to the zone *Cheiloceras amblylobum*, occurring in a ledge of concretions up to 18 inches thick at the type locality (Kirchgasser 1974), is identified in the South Branch of Cattaraugus Creek at elevation 965 feet asl (D5: Gowanda 7½' quadrangle) (House

1967, p.1066 in Tesmer, 1975) and Figure 1, approximately 8000 feet south of the original Gowanda type locality.

Regionally, the bedrock dips less than 40 feet per mile (0.8%) to the south or south-southwest (Tesmer 1975). Therefore, the Corell's Point Goniatite Bed projects from the South Branch north to elevation 1025 feet asl at Grand Finale Rapid (Table 1). Unfortunately, bedrock is missing above elevation 880 feet asl at that location, so its location cannot be verified. If the projection is accurate, then the original Gowanda type locality represents the base of the unit and the Corell's Point bed represents the top, to maintain the reported 270-280 foot thickness.

However, a similar projection from the Corell's Point type locality, Corell's Point, Portland township, Chautauqua County (Brocton 7½' quadrangle) to the Laona Siltstone type locality, Canadaway Creek, Laona, Chautauqua County, New York (Dunkirk 7½' quadrangle) at elevation 800 feet asl places the Corell's Point bed about 190 feet below the Laona Member (Table 1).

Tesmer (9175) states: "At Corell's Point the *Cheiloceras* zone is found in the lower Gowanda but rises higher in the unit when traced eastward into Erie and Cattaraugus Counties." However, Tesmer (1963, p.18) earlier warns: "Some concretionary zones may be traced for distances of several miles, but cannot be used for long-distance correlations." Also, House (1966) identifies two separate Goniatite-bearing concretionary layers in the Gowanda Shale. The above projections support Tesmer's interpretation of a rising zone, but lead to the following questions:

1. How can one sedimentary bed climb through a section of flat-lying conformable sedimentary beds and remain the same bed?

2. Is the bed identified in the South Branch of Cattaraugus Creek the Corell's Point Goniatite Bed or simply a later replication of a similar environment as the Corell's Point environment?

3. Has structural displacement occurred?

Analysis of the Laona Siltstone's reported locations and character raises further questions. According to Tesmer (1975), the Laona "extends from Lake Erie shore in Chautauqua County eastward into western Cattaraugus County where it apparently pinches out near Gowanda."

Based on gas and oil well logs, Van Tyne, et. al. (1980) traces a northeast-trending structure from southwest Chautauqua County, New York through Zoar Valley Gorge and into Erie County, New York with approximately 150 feet of upward vertical displacement at the base of the Dunkirk Shale within the two-mile wide structure at Zoar Valley Gorge. Van Tyne (1999, personal communication) states that the Laona Siltstone is correlative with the base of the Bradford First Sand and that the Shumla Siltstone is correlative with the basal Glade Sandstone.

Finlayson and Ebert (1991) report that the Laona crops out in the South Branch of Cattaraugus Creek at elevation 980 feet asl, based on the occurrence of the Corell's Point

Goniatite bed at the lower falls. The basal contact of the Laona is disconformable on top of the Gowanda shale and "a displacement of 10's of meters of the units in the Canadaway Group is clearly visible on a (normal?) fault within the gorge of the South Branch." The strike of the fault is not reported.

Unpublished work by Mr. Ray Vaughn suggests that the Laona crops out south of the main gorge on the north side of Wickham Road, one mile west of North Otto Road, at the confluence of two ravines flowing toward the gorge at elevation 1330 feet asl.

Projection of the Laona at elevation 800 feet asl from the type locality a distance of 15 miles to the outcrops along Big Indian Creek at elevation 1015-1030 feet asl (Figure 1) supports Tesmer's observations of a very gentle southward dip. However, projection of the Laona from Big Indian Creek another 6.8 miles to Zoar Valley Gorge places the Laona at 835-850 feet asl, the elevations at several of the rapids in the streambed, about 150 feet below the Corell's Point Bed when projected from the South Branch (Table 1). All of the rapids at the intersections of the streambed and the projected Laona occur where the stream flows across jointed siltstone beds.

Could this be the Laona? If so, the bedrock upstream of Pinball Rapid would be the Westfield Shale and the goniatite bed in the South Branch could not be the Corell's Point Bed.

Field investigation by the writer (who strolled up the South Branch to beautiful 5-foot high and 25-foot high waterfalls) revealed at least two concretionary layers and sporadic thin siltstone beds separated by weak shales south of the confluence, below a pyritic siltstone-capped waterfall at elevation 900 feet asl and two siltstone-capped waterfalls at elevation 980 feet asl. About 45 feet above the upper falls, a 30-foot thick siltstone package crops out in the gorge wall at elevation 1025-1055 feet asl. An admittedly brief search produced no goniatites.

At least one strong 130°-145° trending joint set, a small reverse fault and two 20°-30° trending pop-up folds are exposed at stream level. One of the pop-ups may be the feature interpreted by Finlayson and Ebert (1991) as the normal (?) fault. Exceptionally low water revealed continuous beds on both limbs and across the fold axis in the streambed. No significant displacement of beds on the gorge walls was observed.

Projection of the siltstone beds capping the waterfalls and exposed in the gorge walls above the upper falls north a distance of 10,000 feet to the main gorge places the siltstone beds at elevation 1080-1155 feet asl, approximately 210-285 feet above Unnamed Rapid, close to the stratigraphically highest siltstone-capped rapid in the main branch of the Zoar Valley Gorge. Field measurement (Brunton compass) locates a siltstone package at elevation 1060-1150 above Unnamed Rapid, 190-280 feet above the siltstone forming the rapid (Table 1).

As an additional test, a siltstone bed at stream level at the first bend upstream of Forty Bridge on the South Branch occurs at elevation 920 feet asl. When projected 550 feet north to the Confluence, the bed should crop out at elevation 975 feet asl, about 130 feet above stream level. In fact, a siltstone bed does occur at that height above the Confluence, supporting the accuracy of the previous projection.

Projection of the Shumla Siltstone from the type locality at elevation 950 ft. asl on Canadaway Creek (Figure 1) north a distance of 13,000 feet to the Laona Siltstone type locality on the same creek places the Shumla at elevation 1080 feet asl, approximately 280 feet above the Laona Siltstone, found at elevation 800 feet asl. A similar projection of observed Shumla to observed Laona in Big Indian Creek produces approximately 210 feet of separation (Table 1). None of the projections reference known points (top, bottom, marker beds, etc.) within the identified members. Therefore, it is here proposed that 210-280 feet is a reasonable range of separation distances between the Laona and Shumla Siltstones.

Applying the KISS Principle, the projected 210-285 foot separation and measured 190-280 foot separation between the top of the rapids in the main branch and the siltstones of the South Branch suggest that the siltstone unit exposed at and above the upper waterfalls on the South Branch of Cattaraugus Creek may be the Shumla Siltstone, and the siltstone unit exposed along the main branch of Cattaraugus Creek between Pinball and Canoe Eater Rapids is the Laona Siltstone, if the concretionary bed exposed below the upper falls on the South Branch is a later replication of the Corell's Point Goniatite Bed depositional environment, and if the shallow shales absorbed the energy such that no significant structural displacement has occurred at the surface, and if the members of the Canadaway Formation remain relatively flat and consistently thick.

However, if the vertical displacement identified by Van Tyne, et. al. (1980) carries to the surface, then the pyritic siltstone capping the lower falls above Forty Bridge on the South Branch could be the Laona.

Lots of ifs.

Careful stratigraphic section descriptions and measurements, petrographic analyses and structural observations may solve the Mystery of the Missing Laona.

Structural Geology

Zoar Valley Gorge owes some of its sinuousity to cracks and crenulations associated with the Late Paleozoic Alleghenian Orogeny. As previously noted, Van Tyne, et. al. (1980) traces a northeast-trending structure through the gorge. The Bass Island Trend (BIT), a northeast-bearing fracture zone traces the leading edge of the detachment structure at the end of the Allegheny Plateau décollement in Chautauqua County, New York (Beinkafner, 1983), and has been identified in the South Branch of Cattaraugus County (Jacobi, et al., 1999).

At depth the BIT occurs as several sigmoidal thrust/reverse faults rising above the pinchout of a salt zone in the Vernon Formation through Silurian and Devonian sediments to apparently steepen and die out in the weak shales of the Hamilton Group (Beinkafner, 1983).

However, detailed studies of the South Branch of Cattaraugus Creek by Jacobi, et al. (1999) have discovered "clear evidence for faulting in Late Devonian deposits. Steeply-dipping bedding, thrusts with fault gouge and breccia, mesoscopic duplexes, asymmetric kink folds associated with thrusts, and "pop-ups", all striking NE, indicate that thrusts of the Bass Island Trend ramp up to the surface units.

A second set of faults, called here the South Branch Fault System (SBFS), strikes N-S. These high angle faults and monoclines localize hydrocarbon seeps. Stratigraphic offset is on the order of 1-3 m. At least 3 parallel N-S fault zones are evident in the valley and to the east. The faults are segmented by widely-spaced NW-striking fracture intensification zones. NW-striking pop-ups and high-angle faults, with small stratigraphic offset, also occur." Gravity, magnetic and landset data suggest Pre-Cambrian origins for the N and NW-striking features (Jacobi, et al., 1999).

Baudo and Jacobi (1999) note that the "length and height of the NW master fractures is an order of magnitude greater than the NE fractures" in the South Branch.

Beinkafner (1983) identifies a northwest-trending tear fault between adjacent blocks above the BIT thrust fault sole in Chautauqua County. "The significance of the tear fault is that it indicates that the regional arcuate pattern of the structural trends (strike of faults or fold axes) on the Allegheny Plateau is created by differential movement of blocks bounded by strikeslip faults."

Zhao and Jacobi (1997) propose fold-axis-parallel elongation associated with arcuate fold and thrust belts as a mechanism for propagation of syn-orogenic cross-fold joints in the Appalachian Plateau. Their study area in Allegany County, New York focussed on 3 systematic point sets trending 280°-305°, 312-310°, and 322-340°, respectively. Zoar Valley Gorge lies to the west and slightly north of their study area.

Review of several logs of gas wells drilled close to the gorge has revealed a thin salt zone at depth, supporting Beinkafner's model of BIT structures above a thin to absent salt-zone (Dahl, 1999, personal communication).

Field investigation by the writer (more strolls along the South Branch and the main branch of Cattaraugus Creek) have revealed five distinct fracture trends, N (350°-10°), NE (20°-40°), ENE (60°-70°), E (80°-110°) and NW (310°-330°) (Figure 5). Personal communication with R. Jacobi (1999) suggests the following sequence from oldest to youngest: NE/ENE, E, N and NW. NW, NE/ENE, N? and E? The fractures either control the streambed as parallel-flow chutes or cross the streambed as ledges in the rapids or simple fractures between rapids. Table 2 summarizes the orientations of joints in the rapids in the main branch. A NE pop-up fold occurs at the head of Curly, Larry and Moe Rapid. A N70E15SE thrust fault(?) with minimal displacement occurs at the first sharp bend, upstream of Pinball Rapid.

In the South Branch, an E joint forms a chute in the streambed approximately 2000 feet upstream of the Forty Bridge. ENE joints control the stream channel for 1000 feet above the confluence. Strong NE features control the stream bed as joints between the confluence and the Forty Bridge, and as a tight fold between the easternmost bend and the upper falls. A NE joint set occurs in the Main Branch on strike with the tight fold between the easternmost bend and the upper falls. A NE pop-up fold occurs downstream of the easternmost bend. N joints control the streambed immediately downstream and upstream of Forty Bridge, at the confluence, and downstream of the easternmost bend. NW joints cut the channel downstream of Forty Bridge and upstream of the easternmost bend, and control the streambed between the second and third bends above the Confluence and upstream of Forty Bridge to the big bends.

In summary, E, ENE and NE features exert significant influence on streambed orientation in the main branch until truncated by a strong NW fracture zone as Cattaraugus Creek leaves the gorge to occupy the ancestral Allegheny River Valley. In the South Branch downstream of the falls, NE and N features control the channel except where cut by a strong NW fracture zone.

In eight curious instances the streambed follows continuous strong joint sets as they bend though 20°-50° of arc. In the main channel, from the first sharp bend to Pinball Rapid, strong joint sets bend from 25° to 45°, 60° to 80° and 275° to 290°. Above Turtle Rock Rapid, the joint set and streambed bend from 40° to 70°. In the South Branch between Forty Bridge and the confluence, the joint sets and streambed bend from 355° to 15° back to 25°, then 0° to 330°, then 25° to 75° just above the confluence. The bending joints cut both shale and siltstone, but predominate in shale. In all five cases, the bending joints are cut by strong NW joints.

Here are some questions:

1. What types and sequence of stresses would cause both clockwise and counterclockwise rotation on continuous joints?

2. If the NW zone is a tear fracture associated with the Bass Island Trend, are the bending joints pre-tear indicators of complex stress distributions across a weakening zone in fissile shales and thin siltstones or curving perpendicular intersections, indicating that the NW fractures came first?

Glacial History

Zoar Valley Gorge incises the bedrock beneath the trace of an ice marginal meltwater channel parallel with, and adjacent to, the Valley Heads Moraine (VHM). Subsequent ice recession allowed the young Cattaraugus Creek to breach the moraine and occupy the pre-glacial Allegheny River Valley in Gowanda. Surficial deposits and landforms provide clues to the sequence of events leading to gorge formation, but present more mysteries.

Fairchild (1932) worked out a progressive sequence of Pleistocene meltwater channels across Cattaraugus County. Proglacial lakes occupied a series of north-flowing pre-glacial (Tertiary?) valleys dammed by the VHM. Progressively lower outlets were exposed as the ice receded, draining the lakes and cutting three gorges along Cattaraugus Creek. The presently studied gorge is the furthest downstream. The middle gorge occurs due north of East Otto. The upper gorge occurs south of Springville and can be viewed from U.S. Route 219 (Figure 1). All three gorges lay beneath meltwater channels cutting uplands between ice-or moraine-dammed north-flowing valleys (Fairchild, 1932).

A lake in the valley east of Zoar Valley Gorge and in the Skinner Hollow section of the South Branch drained through an outlet at Persia (el. 1320), until a mid-valley rise (moraine?) was exposed at elevation 1340 feet asl (Cuthbert, 1937). A further recession allowed the north half of the lake to join the Skinner Hollow section of the South Branch via a channel between the VHM and the bedrock upland, as indicated by the soils present (Figure 6).

A Chenango gravelly loam terrace straddles the Forty Road/Wickham Road intersection at elevation 1340 feet asl east of the South Branch, and terraces of Mentor fine sandy loam are distributed east of the South Branch about elevation 1340 feet asl between Forty Road and Skinner Hollow Road. The Soil Survey of Cattaraugus County, New York (1940) describes Chenango gravelly loam as stratified sand and gravel subsoil, deposited by water as stream terraces, outwash plains and deltas.

Mentor fine sandy loam is described as gravel-free fine sand subsoil, deposited as terraces and deltas in glacial lakes, underlain by heavy blue lake clay at a depth of 8-10 feet. Arkport very fine sandy loam occurs along the north rim of the gorge. The Soil Survey of Erie County describes Arkport (very fine sandy loam) as very fine to fine sandy loam subsoil deposited in sandy deltaic and lacustrine sediments.

Thus, water flowed west along the trace of the present main gorge and south along the trace of the presently north-flowing South Branch gorge, lazily depositing fine sands between the bedrock upland and the VHM, as it drained through the Persia outlet into the Conewango Valley. The Conewango Valley, itself once occupied by the pre-glacial north-flowing Allegheny River, previously diverted at Steamburg, New York by an earlier glacial advance (Tesmer, 1975), drained through Kennedy, New York to the Allegheny River. Later ice retreat opened progressively lower outlets northwest of Perrysburg, allowing deeper incision through the overlying sediments into the bedrock until the present day.

This seems straightforward, but there's a twist.

The Persia outlet is bounded on the north by a multiple looping moraine composed of reworked (?) lacustrine clay that extends east to the Big Bend of the South Branch and west to Dayton, New York (Figure 6). Tesmer (1975) noted lithologic similarities between the moraine and the Defiance (?) moraine in Chautauqua County. However, the upstream drainage system described above developed in response to the VHM. Also, the looping moraine is the largest topographic barrier across the northern Conewango Valley, characteristic of the VHM across the state. Furthermore, a large commercial sand and gravel mine occurs within a mile of the outer loop of the moraine, also characteristic of the VHM. It would seem that the looping moraine is the VHM.

However, if the moraine is composed of reworked lacustrine sand and clay, then the clay must have been bulldozed by the ice, requiring recession from the outer loop and a subsequent re-advance sufficient to plow up clay 100 feet above the valley floor. A second loop segment occurs west of the outer loop. This raises a question: To where did the lake waters drain prior to the re-advancement?

Two commercial gravel pits, located north of the Forty Road/Point Peter Road intersection in Cattaraugus County and south of the Vail Road/Allen Road intersection in Erie County, respectively, (Figure 6) may provide clues. The Point Peter Pit exposes well graded sands and gravels apparently dipping 15° NW in a delta-like geometry with surface elevation of 1270 feet asl. The Vail Road Pit exposes a similar deposit apparently dipping 30° NW with a surface elevation of 1140 feet asl. Both deposits are capped with a five-foot thick layer of stony till (?), suggesting later ice re-advancement. Since the only outlets low enough to establish base levels for the deltas are west of Perrysburg, perhaps recession allowed westward drainage.

The apparent dips of the sand and gravel beds raises another question: why do outwash-like deposits dip toward the ice? Perhaps the deposits grew as inwash from the captured drainage of the Cattaraugus Creek and South Branch meltwater channels. First the South Branch could have built the Point Peter deposit after breaching the outer loop moraine or pouring through a void left by retreating ice, reversing its flow from south to the Persia outlet to north to build the

Point Peter delta, then west past Perrysburg. A series of patches mapped as Chenango soils near elevation 1200-1250 feet asl arcing across the Conewango Valley from the Point Peter delta toward Perrysburg may trace one or more meltwater channels. Further field work is necessary (an understatement). Further recession could have lowered base level sufficiently to allow Vail Road delta deposition by the main branch, or by the South Branch.

Subsequent ice resurgence reworked the tops of the Point Peter and Vail Road deposits, which raises other questions: Where's the resurgent moraine? Some summit alignment east of Point Peter Road and south of Forty Road may mark the moraine, but north of Forty Road, the South Branch flows north where one would expect the moraine. Why weren't the apparent meltwater channels arcing across the valley destroyed? Do they represent post-resurgence drainage?

Now here's a puzzling one: why did the South Branch cut across the head of the Point Peter delta to join the main branch, instead of flowing west around the delta, presumably down gradient, as base level declined? Did resurgent ice push the stream east? If so, how could base level be low enough to encourage downcutting? Did a buried ice block melt after delta deposition and resurgence? No kettles or other stagnant ice features have been found. However, unpublished soils data from the U.S.D.A. Natural Resources Conservation Service show Valois gravelly silt loam to occur east of the South Branch from elevation 1100 feet asl to the bedrock upland. The Soil Survey of Erie County describes Valois gravelly silt loam to occur on undulating reglaciated outwash moraines and other moraines. If an ice block was buried by inwash gravels, subsequent melting could leave an undulating slope as found. Are tectonic forces at work? The streambed of the South Branch closely follows NW joints to Forty Bridge, then N to NE joints to the confluence with the main branch. Jacobi, et al. (1999) reference six seismic events along the N-S trend, with three located at intersection with NW lineaments. Could a buried ice block have filled a pre-existing structural depression? Is there another, completely different explanation?

The writer doesn't know, but will pursue these questions as time allows.

Geomorphology

Cattaraugus Creek flows west across very slightly (less than 1%) south-dipping Late Devonian Canadaway Formation shales and siltstones of the Allegheny Plateau. Although the physiography of upstate New York is cuestaform, with resistant escarpments separated by weak fine-grained sediments, Cattaraugus Creek is not a typical subsequent stream. The stream traverses at least three pre-glacial north-flowing obsequent stream valleys dammed by the VHM to the north at Sardinia, Springville and north of East Otto, then crosses the moraine and re-occupies the pre-glacial Allegheny River Valley at Gowanda until it discharges into Lake Erie (Figure 1). In crossing the VHM moraine east of Gowanda, Cattaraugus Creek is the only stream in western New York, other than the Genesee River, to breach the continental divide between the Mississippi River and the St. Lawrence River watersheds. The stream connects the pre-glacial valleys via meltwater channels across intervening uplands. Zoar Valley Gorge is the westernmost of the channels.

Fairchild (1932) describes the trace of Zoar Valley Gorge as "intrenched meanders" in the bedrock, inherited when lowering base levels allowed incision through the overlying glacial sediments into the soft shales and thin siltstones of the Canadaway Formation. While probably true throughout the slightly meandering upper miles of the gorge, structural control appears to exert increasing influence downstream.

The first significantly larger and sharper meander occurs about 10,000 feet west of the head of the gorge, on strike with a major NE fold/joint set observed in the South Branch. Unfortunately, the writer's strolls did not reach the first large meander at the time of this writing. Perhaps by meeting time, more data will be available. Alternatively, if sufficient water flow allows a raft trip, the participants can look for NE joints or other trends as we paddle.

Continuing downstream, the amplitude of the meanders increases. Strong joint sets, trending E and NW at Unnamed Rapid, NW, E and ENE at Refrigerator Island, NE at Lunchstop Hole, NE and NW at Confluence, NW at Curly, Larry and Moe, and E at Canoe Eater Rapids in the gorge, and NW at Turtle Rock, N at Shotgun Ledge, NW at Redline Slot, NW at Glue Factory and NW at Grand Finale Rapids downstream of the gorge, form chutes that channel streamflow. The sharp bends at Unnamed Rapid, Refrigerator Island and Confluence follow strong joint sets. Practically the entire reach of the South Branch from the upper falls to the Confluence follows strong NE, N, NW and ENE joint sets, either as chutes, at stream bends, or both.

Therefore, it is here proposed that pre-existing joints have exercised increasing influence over stream channel direction after erosion exposed bedrock. The young Cattaraugus Creek meandered across the essentially flat-lying rocks until flow concentrated erosion at zones of weakness, as suggested by the plateau north of Valentine Flats Road (Figure 2).

Valentine Flats itself piques curiosity. The gorge walls are roughly twice as far apart at the Flats as they are upstream or downstream. Relict meanders along the west wall do not well match the east wall. At the upstream end of the Flats at Curly, Larry and Moe Rapid rises the Pyramid, an impertinent pinnacle 120 feet high beveled on all three sides similar to the gorge walls (Figure 2). All the walls have been eroded to the same elevation. And so, the inevitable questions:

1. Did the South Branch once flow between the Pyramid and the west wall, joining the main branch downstream of the Pyramid? Perhaps a thin wall separating the branches upstream of the Pyramid eroded away, allowing confluence further upstream and creating the Pyramid.

2. Why don't the relict meanders match?

3. How was the west wall carved obliquely to the Pyramid?

4. Did the main branch once flow between the Pyramid and the west wall? If so, how can the present configuration be explained?

Weird stuff. The writer will pursue these questions, too.

<u>Rapids</u>

Cattaraugus Creek drops approximately 40 feet from the head of Zoar Valley Gorge to the top of Pinball Rapid over a stream distance of 15,000 feet at a gradient less than 0.3% with no rapids. From Pinball Rapid to the mouth of the gorge above Turtle Rock Rapid, the stream drops approximately 100 feet over a stream distance of 16,000 feet at an average gradient of 0.6%. Practically all of the 100 feet of drop occurs in twelve sections of rapids comprising approximately 5425 feet of stream distance at an average gradient of 1.8%. From the mouth of the gorge above Turtle Rock Rapid to the bottom of Grand Finale Rapid, the stream drops approximately 40 feet over a stream distance of 9000 feet at an average gradient of 0.4%. Practically all of the 40 feet of drop occurs in seven sections of rapids comprising approximately 3104 feet of stream distance at an average gradient of 1.3%.

Table 1 summarizes various characteristics of the nineteen individual rapids. Several general observations can be made.

1. Of the fifteen rapids across bedrock, ten are capped by siltstone.
2. Thirteen rapids are strongly influenced by joints, either as cross-flow ledges or parallel-flow chutes.
3. Seven rapids occur at bends.
4. Twelve rapids cross "rock gardens", cross channel cobble/boulder bars.
5. Eight rapids combine rock gardens and bedrock chutes or ledges.
6. Six rapids at bends have rock gardens at the top of the rapid with pools immediately upstream, and bedrock ledges and/or chutes downstream of the rock gardens.
7. With the exception of Redline Slot, the steepest drops occur across the four rock gardens not visibly associated with bedrock.
8. Five rapids occur around mid-channel islands.
9. E, ENE or N joints strongly influence the upper rapids.
10. NW joints strongly influence the lower rapids.

What do these observations mean?

There is a strong correlation between rapids, siltstone beds, joints and rock gardens. While rapids, resistant beds and fractures make sense, the occurrence of rock gardens at the heads of rapids seems contradictory: as the gradient increases, velocity increases, as does stream competence. Why does deposition occur instead?

The occurrence of upstream pools suggest that classic pool and riffle stream morphology is at work, even though the streambed is bedrock. Glacial erratics are common constituents of the rock gardens, indicative of a large bedload expected so close to upstream moraines and outwash plains. During high water times, perhaps Cattaraugus Creek scours the soft shale in the streambed, then deposits the bedload as the current meanders upward through the water column. If, on the following downward flex, the current encounters more resistant siltstone, lateral migration and erosion of shales exposed in the bank would be encouraged, spreading the flow and encouraging further bedload deposition as mid-channel islands, point bars, or rock gardens. When a fracture zone is encountered in the siltstone, downward erosion could re-commence, focussed along the fracture zone in a chute or into the softer underlying shale once the siltstone has been removed downstream of the fracture, leaving a ledge. Unnamed, Refrigerator Island, Confluence, Canoe Eater, Turtle Rock and Redline Slot Rapids are examples. More study is required.

Flow direction and bedrock dip creates a unique situation. In two reaches, Pinball to Unnamed and Refrigerator Island to Lunchstop to Confluence, the stream flows consequently across siltstones. As a result, the stream may cut the same siltstone bed two or three times in a pool and riffle pattern. Detailed petrographic analysis and section measurement is necessary to verify these occurrences.

The writer will also pursue these investigations.

Acknowledgments

The writer sincerely thanks field partners Ms. Wendilorion Meyers, Ms. Amanda Joy Meyers and Mr. Rick White for their sweat and laughter while surveying the rapids, Dr. Robert Jacobi, Dr. James Ebert, Dr. Gordon Baird, Mr. Art Van Tyne and Mr. Ray Vaughn for providing references and insights, Mr. Jack Dahl, Mr. John Hoffman and Ms. Tracy Johnson, NYS DEC, for providing insights and technical support, Mr. Keith Scheetz and Mr. Rich Pecnik, Gernatt Asphalt Products, Inc. for providing information on area gravel deposits, JWS for teaching skepticism, DCM for teaching professionalism and most of all, my wife, Ms. Laura Kay Meyers, for putting up with me.

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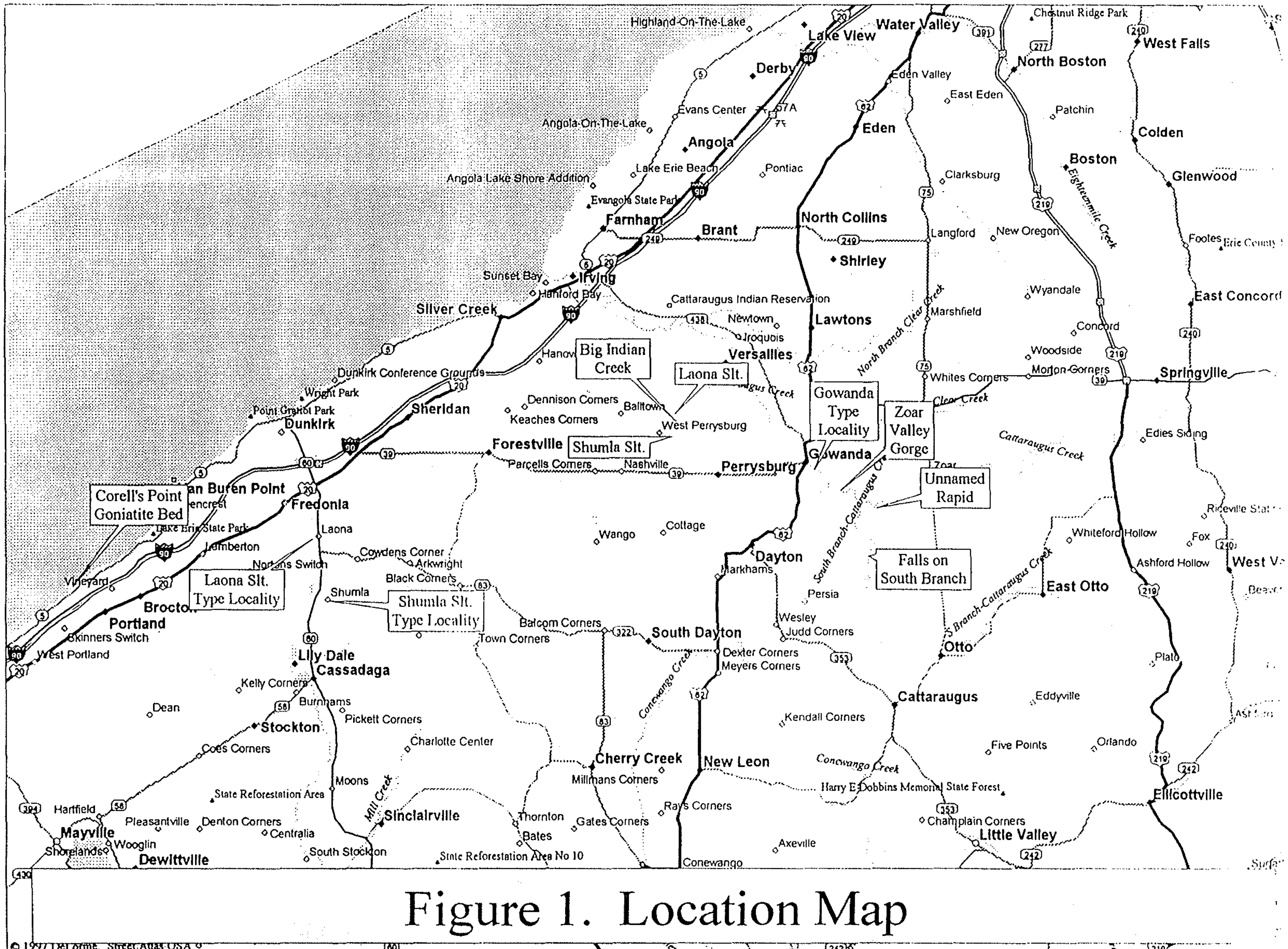
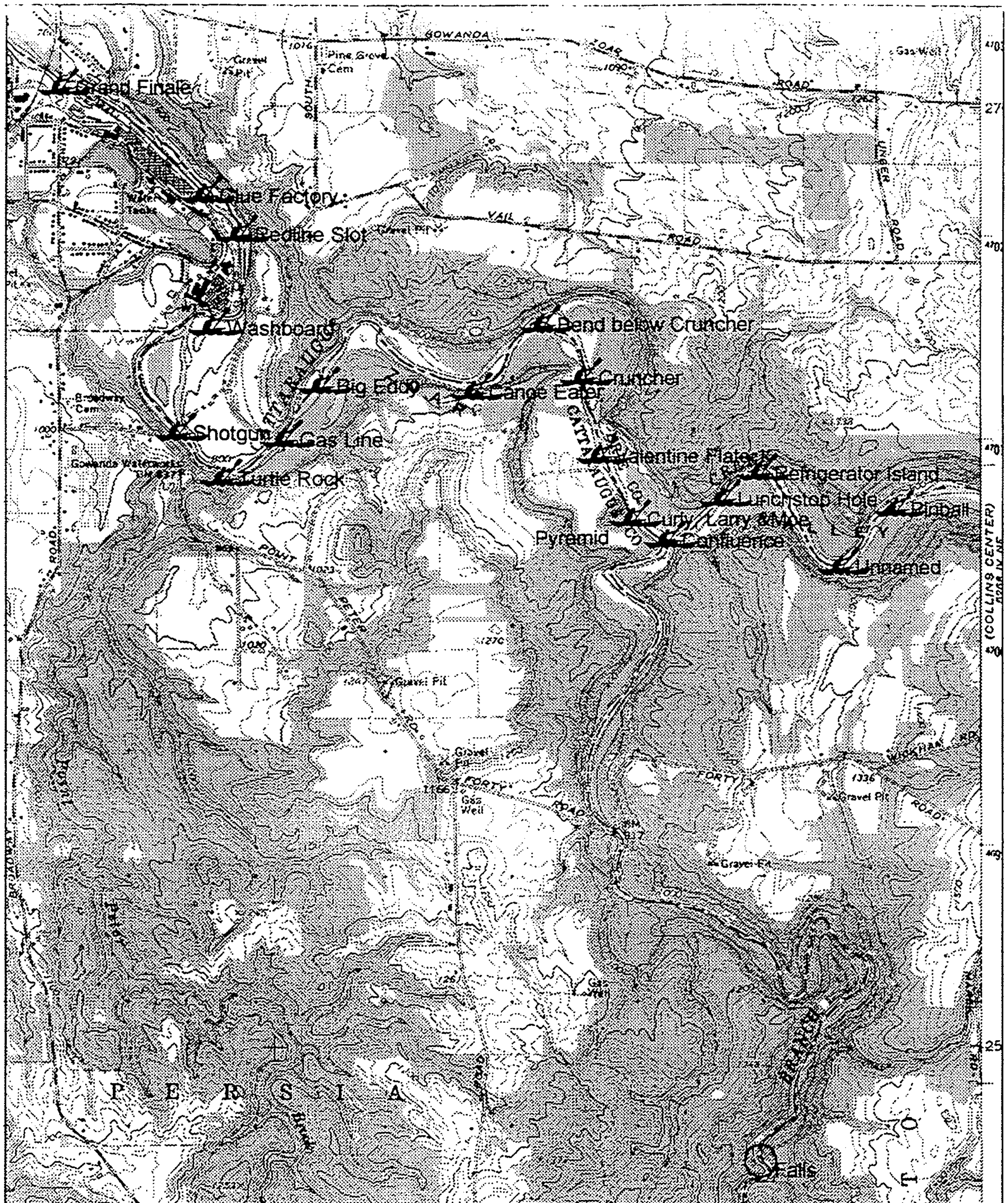


Figure 1. Location Map



Name: GOWANDA
Date: 8/2/99
Scale: 1 inch equals 2000 feet

Location: 042° 26' 10.2" N 078° 54' 11.1" W
Caption: Figure 2. Rapids of Zoar Valley Gorge, Cattaraugus Creek, NY

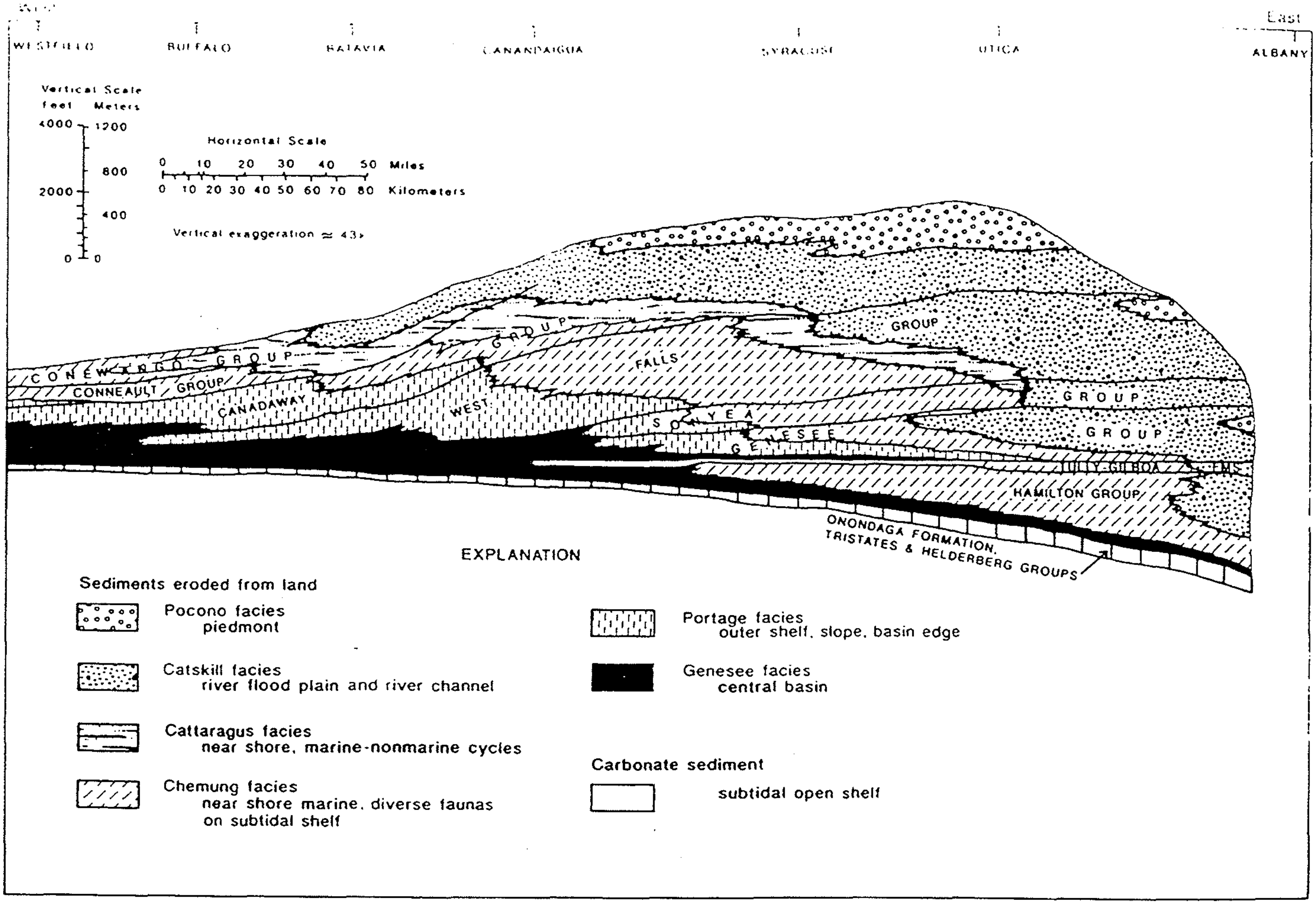


Figure 8.16. Diagrammatic cross section of the "Catskill Delta" east-west across New York State. This diagram is a composite that uses information from the outcrops in New York and in northern Pennsylvania. The cities listed across the top of the diagram generally are north of the main body of the cross section. A line drawn south from a city will cross the facies shown below it, starting with those facies at the bottom of the diagram. The "delta" deposits are divided into groups. Each group includes several facies. Figure 8.15 shows the environments where the different facies developed. Each group records an episode of the "delta's" construction. For example, as the Genesee Group was deposited, the shore zone moved from east to west as the sediment filled in the sea. An abrupt increase in the depth of the water moved the shore zone back toward the east, and deposition of the Sonyea Group began. The opposing processes eventually built the complex of sedimentary rock we call the "Catskill Delta." Notice that this diagram is distorted because the vertical scale is much larger than the horizontal scale. This vertical exaggeration is necessary to show details. However, it gives a false impression because it exaggerates the thickness relative to the width of the units shown.

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Figure 3: From Geology of New York, A Simplified Account, 1991, Educational Leaflet No. 28, SUNY State Education Department

Figure 4: From Geology of New York, A Simplified Account, 1991, Educational Leaflet No. 28, SUNY State Education Department

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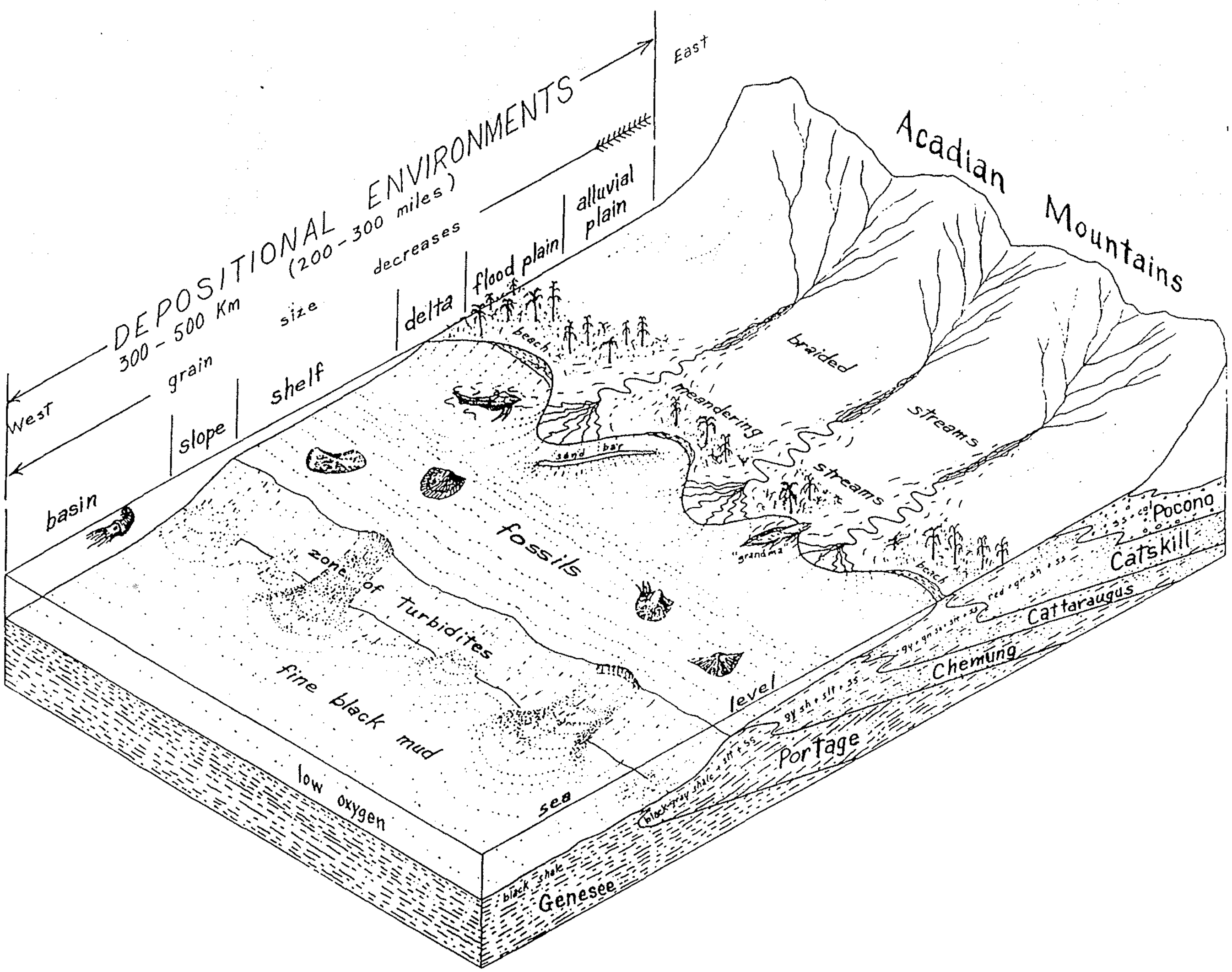
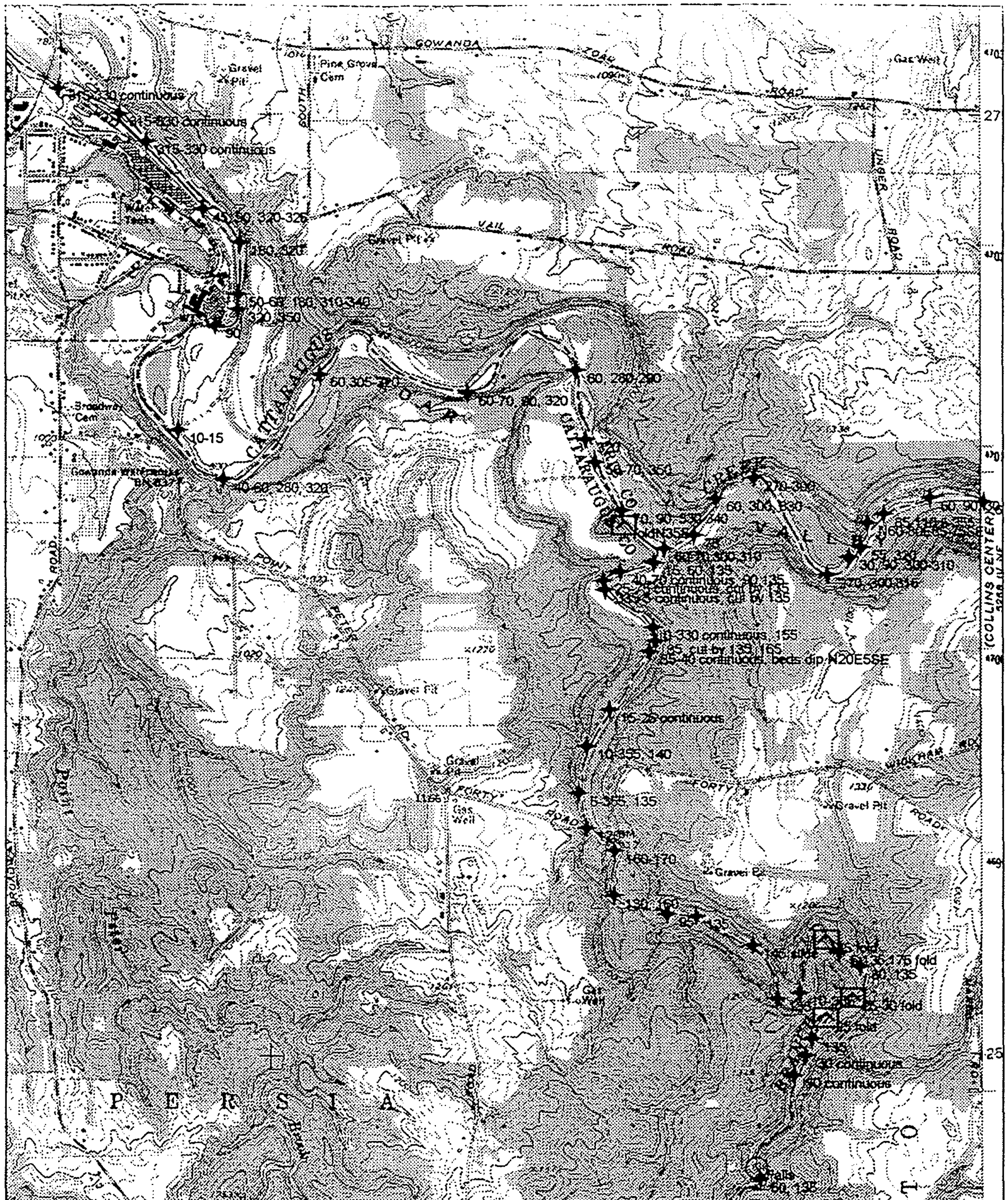
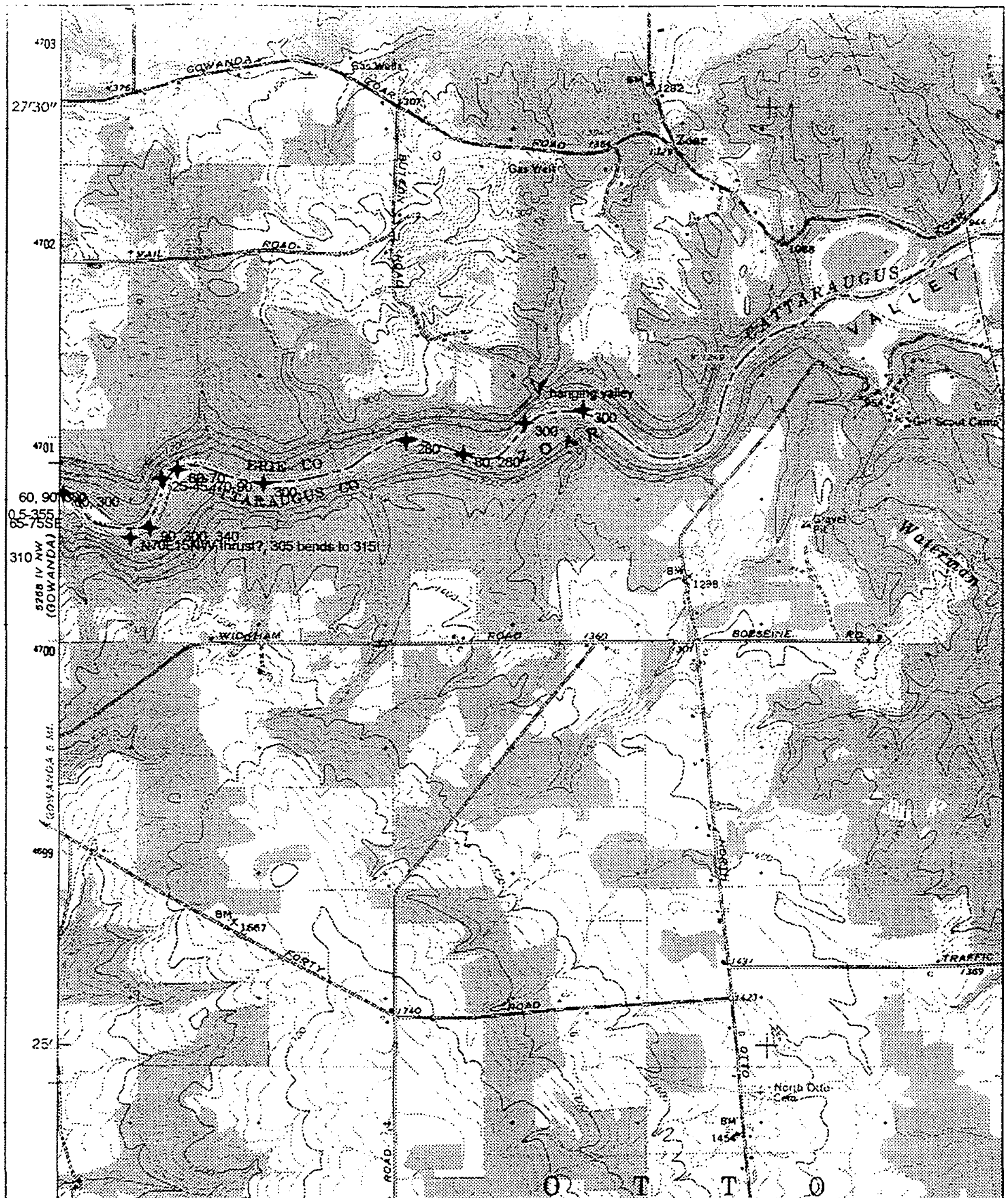


Figure 8.15. Diagram of the depositional environments of the "Catskill Delta" and the facies that were deposited in them. The arrangement of the facies (Genesee-Pocono) shows that the environments have moved from right to left through time as the sediment has filled in the edge of the sea. This process could be reversed by a rise in sea level, which would move the shore zone toward the right. (In this oversimplified diagram, the Pocono facies looks as if it were underneath the Acadian Mountains. It was actually deposited at the foot of the mountains.)



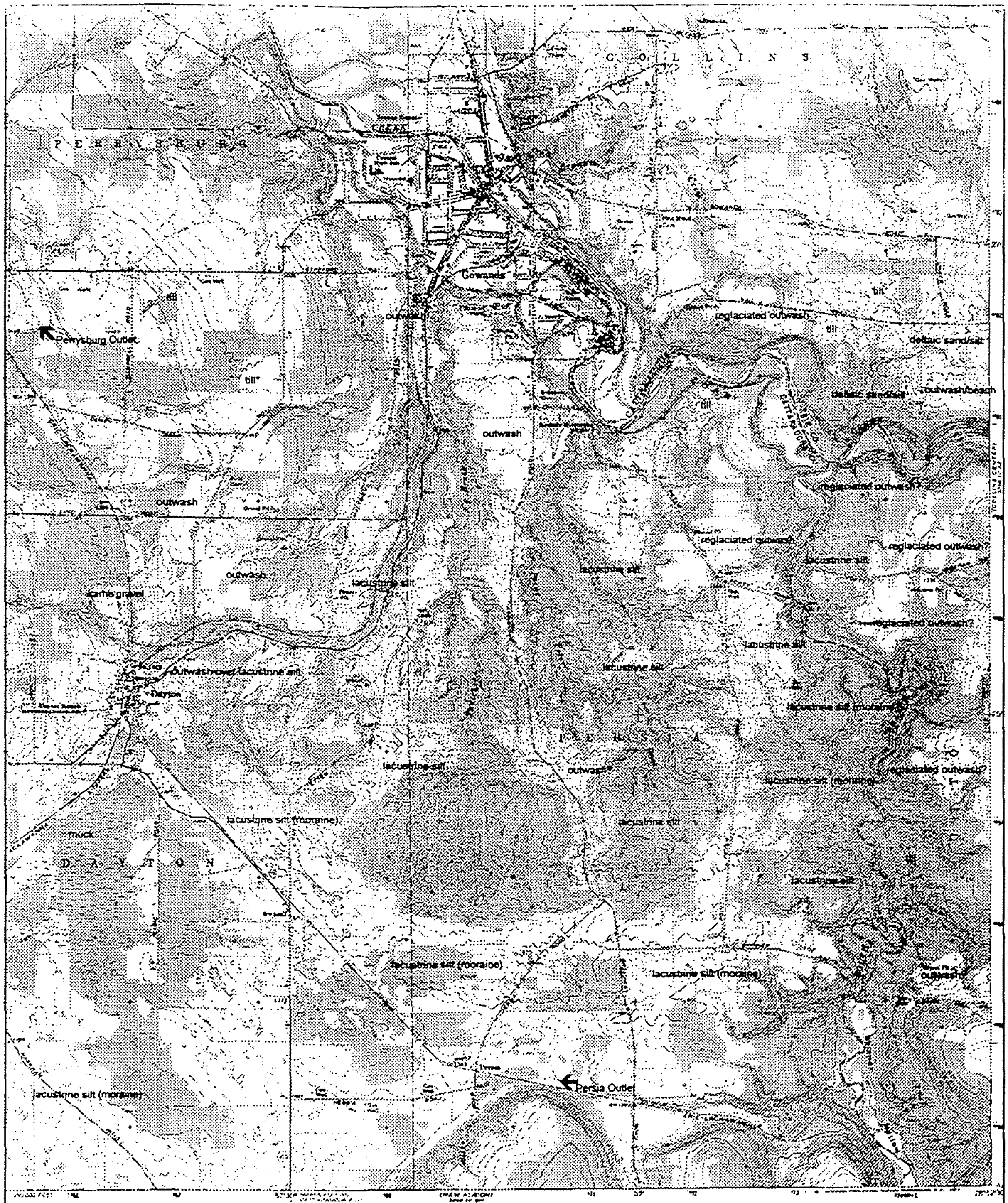
Name: GOWANDA
Date: 8/9/99
Scale: 1 inch equals 2000 feet

Location: 042° 26' 11.6" N 078° 54' 11.1" W
Caption: Figure 5. Joint and Fold Orientations, Zoar Valley and South Branch Gorges, Cattaraugus Creek, NY (west)



Name: COLLINS CENTER
Date: 8/9/99
Scale: 1 inch equals 2000 feet

Location: 042° 26' 10.6" N 078° 50' 55.4" W
Caption: Figure 5. Joint and Fold Orientations, Zoar Valley and South Branch Gorges, Cattaraugus Creek, NY (east)



Name: GOWANDA
Date: 8/17/99
Scale: 1 inch equals 4000 feet

Location: 042° 25' 35.4" N 078° 55' 55.9" W
Caption: Figure 6. Preliminary Surficial Geology Near Zoar Valley Gorge, Cattaraugus and Erie Countie, NY

TABLE 1
PROJECTION OF SHUMLA SILTSTONE, LAONA SILTSTONE AND CORELL'S POINT GONIATITE BED FROM TYPE LOCALITIES TO ZOAR VALLEY GORGE

	CORELL'S POINT		SHUMLA		LAONA		BIG INDIAN CREEK		SOUTH BRANCH GORGE CATTARAUGUS CREEK			ZOAR VALLEY GORGE CATTARAUGUS CREEK		
UNIT	LAT/LONG	ELEV.[1]	LAT/LONG	ELEV.	LAT/LONG	ELEV.	LAT/LONG	ELEV.	LAT/LONG	ELEV.		LAT/LONG	ELEV.	
										(proj.)	(loc.)		(proj.)	(loc.)
Shumla Siltstone	---	---	42°23'11"/ 79°17'56"[2]	950[2]	---	1080[2]	42°28'19"/ 79°1'28"[3]	1185[3]	42°24'42"/ 98°53'17"[7]	1040[6]	980-1055[7]	42°26'15"/ 78°53'2"[7]	1140[6]	1060-1150[7]
Laona Siltstone	---	---	---	---	42°25'15"/ 79°18'37"[2]	800[2]	42°29'26"/ 79°1'52"[3]	1015-1030[3]	42°24'42"/ 78°53'17"[5]	980[5]	---	42°26'15"/ 78°53'2"[7]	860[6]	840-870[7]
Corell's Point Goniatite	42°24'51"/ 79°26"57"	550	---	---	---	690[6]	42°30'54"/ 79°2'37"[3]	800[4]	42°24'43"/ 78°53'18"[4]	650[6]	965 [4]	---	---	---

(1) elevation in feet above sea level
(2) from Tesmer, 1963
(3) from Tesmer, 1975
(4) from House, 1967
(5) from Finlayson and Ebert, 1991
(6) projected in this study from type locality assuming 1% dip to south, uniform thickness of beds
(7) siltstone outcrop located in this study

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TABLE 2
ZOAR VALLEY GORGE RAPIDS

				GRADIENT (%)				
RAPID	TYPE	DROP (FT)	LENGTH (FT)	AVE.	IN CHUTE	JOINTS	ROCK TYPE	COMMENTS
1. Pinball	l/rg	9.1	698	1.3	2.0	**85-110**, 5-355	slt	90° l at top; chute cuts across mid-channel rg
2. Unnamed	rg/l	9.4	544	1.7	2.1	**90**, 300, 315	slt	rg at top; 90° l at bend; 90° joints form chute
3. Refrigerator Island	rg/l	11.9	916	1.3	1.9	**80-90**, 300	slt	rg at top; 90° l at inside bend around mid-channel island
4. Lunchstop Hole	chute	6.2	249	2.5	2.5	**60**, 300, 330	slt	60° joints form chute along straight stretch
5. Confluence	rg/l	6.6	302	2.2	2.2	**60-70**, 80-115, 300, 310	slt	rg at top; 70° l's cut by 315° joint
6. Curly, Larry & Moe	chute	8.9	488	1.8	2.2	35, 70, 90, **330-340**	slt	35° pop-up at top; 330-340° joints form chute along straight stretch
7. Valentine Flats	l	6.3	595.9	1.1	--	45, **310**	sh	310° l's across weak shales along straight stretch
8. Cruncher	l/rg	11.8	516	2.3	--	**60**, 100-110	sh	60° l above rg
9. Bend Below Cruncher	rg	3.0	62	4.9	--	--	--	rg at bend
10 Canoe Eater	rg/l	12.9	775	1.7	1.9	60-70, **90**, 320	sh	rg at top; 90° l at outside bend, forms chute around mid-channel island
11. Big Eddy	rg	7.5	135	5.6	--	--	--	rg at top of mid-channel island
12. Gas Line	rg	7.8	145	5.4	--	--	--	rg at bottom of mid-channel island
13. Turtle Rock	rg/l	7.7	508	1.5	1.5	0, 40-60, **100**, **320**	slt	rg at top; 100°, 320° joints form chute
14. Shotgun (Upper)	l	4.8	276	1.7	1.7	**10-15**	sh	10°-15° joints form chute
15. Shotgun (Lower)	rg	4.3	156	2.8	--	--	--	rg adjacent to mid-channel island
16. Washboard	roll	3.0	114	2.6	--	--	sh	stream flows over N55E10NW monocline
17. Redline Slot	rg/l	2.5	35	7.1	7.1	**315**	slt	rg at top; 315° joints form chute
18. Glue Factory	l	5.5	407	1.4	1.4	**45**, 90, **320-325**	slt	45° l; 320° joints form chute
19. Grand Finale	l	12.0	1608	0.7	2.3	**315-330**	slt	315°-330° joints form chute

ROAD LOG
GEOLOGY OF THE ZOAR VALLEY GORGE OF CATTARAUGUS CREEK, CATTARAUGUS AND ERIE COUNTIES, NY

MICHAEL J. MEYERS
NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION

Enroute to Zoar Valley Gorge, we will visit the type localities of the Corell's Point Goniatite Bed of the Gowanda Shale Member and the Laona Siltstone Member of the Canadaway Formation. We will also pass a sand and gravel pit in a glacial Lake Whittlesey beach deposit, with excellent concurrent reclamation to a vineyard, climb from the Lake Erie Plain onto the Allegheny Plateau, cross the Valley Heads Moraine (VHM) and pass another sand and gravel deposit located downgradient of the VHM on top of the lake sediment-filled pre-glacial Allegheny River Valley, now occupied by Conewango Creek. We will re-cross the VHM and drop into Gowanda through deeply dissected lake sediments, then visit the type locality of the Gowanda Shale Member of the Canadaway Formation, located at Grand Finale Rapid on Cattaraugus Creek, stop at a gravel pit with stratified sands and gravels dipping back toward the ice, then park at Forty Bridge on the South Branch of Cattaraugus Creek. We'll hike a total of three miles through the South Branch gorge to observe surface expressions of the Bass Island Trend, rapids along the main branch of Cattaraugus Creek, possible outcrops of the Laona and/or Shumla Siltstones and other natural beauty in the spectacular Zoar Valley Gorge.

The above itinerary assumes insufficient flow for a white water raft trip. If we are blessed with water, then we'll skip the Corell's Point, Laona and Shumla type localities and the gravel pits, drive to Gowanda to Zoar Valley Canoe & Rafting Co., Water Street, change into wetsuits (remember dry clothes, towel and shoes), pick up paddles & life jackets, catch the bus to the put-in, paddle the gorge and experience Zoar Valley the way we should. So pray for rain...

TOTAL MILES	MILES FROM LAST POINT	ROUTE DESCRIPTION
0.0	0.0	Leave the Fredonia campus at the Temple Street exit. Turn right (north) onto Temple Street.
0.4	0.3	Y-Junction; turn right (north) on Brigham Road.
0.9	0.6	Cross New York State Thruway.
1.5	0.6	Enter City of Dunkirk.
1.7	0.2	Pass Al-Tech Corp. factory (to right).
2.7	1.0	Junction with Route 5; turn left (southwest).
2.9	0.2	Turn right onto Point Drive North.
3.9	1.0	Cross Canadaway Creek.
7.5	3.6	County Fly Ash Dump to the left.
8.6	1.1	Bridge over Little Canadaway Creek.
9.4	0.8	Entrance to Lake Erie State Park.
11.3	0.9	Bridge over Slippery Rock Creek. Exposures include the South Wales Member at the lake shore level and Gowanda Member at the bridge and upstream.
12.2	0.9	Bridge over Corell Creek. Exposures are in the Gowanda Shale Member. The Corell's Point pyrite-goniatite bed is exposed approximately 120 feet upstream from the bridge.
13.3	1.1	Turn right (northwest) onto property of trailer court. Proceed 0.1 mile. Park at beach by boat ramp and proceed on foot across small creek and along shore for approximately 100 yards.

IMPORTANT: The landowner requests that no turtle rocks be whacked on or removed.

STOP 1: CORELL'S POINT PYRITE-GONIATITE BED IN GOWANDA MEMBER (description from Baird and Lash, 1990)

The Corell's Point Pyrite-Goniatite Bed, encompassing two regionally mappable levels of calcareous septarian concretions, is present at several creek localities in this county but this shore exposure is the best place to examine fossils and sedimentary structures (Fig. 4 B,C.). At least two, laterally discontinuous beds rich in pyrite nodules and locally abundant pyritized cephalopod steinkerns can be traced within the lower septarian concretion zone along the shore and around the small headland. Goniatites include Cheiloceras amblylobum, tornoceras concentricum, and Aulatornoceras bicostatum (Fig. 4C); these belong to the zone of Cheiloceras (II) in the amennian (see House, 1966; Kirchgasser, 1974). Orthoconic cephalopods are also common; these are commonly encrusted by a reptate auloporid coral. Slightly-curved conical shells less than one inch in length may be bactitid cephalopods or coleolid tubes. Bivalves, including Lunulicardium eriense, Praecardium multicostatum and Loxopteria corrugata occur with the cephalopods but these are usually preserved as non-pyritic composite molds often with a faint organic patina which may be a remnant of the periostracum layer. Driftwood, usually partly carbonized and partly permineralized by pyrite, occurs with the other fossils. Spectacular large Zoophycos spreiten in the Corell's Point Bed indicate that this trace had become important in offshore, dysoxic facies by the Famennian.

Babcock (1982), believed that the fauna of this bed was selectively preserved by turbiditic smothering events; some beds in this unit have shallow sole marks and display lamination similar to those in flaggy siltstone beds elsewhere in the Canadaway Formation. However, evidence of periods of reduced sediment influx is shown by intense biotrubation at some levels and by the tendency for auloporid corals to not only colonize partly-buried cephalopods but to extend colonial growth onto the adjacent seafloor. The history of this unit is complex and the presence of so many fossils at this level is suggestive of an episode of increased bottom oxygenation and reduced average turbidity.

The Corell's Point Bed is well exposed in Corell's Creek, Slippery Rock creek near Brocton, Little Canadaway Creek near Lamberton, Canadaway Creek upstream from Route 20, and Walnut Creek at Forestville (House, 1966, 1968).

Examine the Gowanda strata both below and above the Corell's Point Bed; notice the numerous brown-black shale beds which alternate with grey-green mudstone to produce the conspicuous striped banding along the shore (Fig. 4B).

Return to the vehicle(s). Leave trailer park and turn left (northeast) onto Route 5.

TOTAL MILES	MILES FROM LAST POINT	ROUTE DESCRIPTION
14.5	12.0	Junction with Pecor Road. Turn right (southeast). Proceed across sandy lake sediments.
15.1	0.6	Cross NYS Thruway.
15.5	0.4	Cross railroad tracks. Climb onto glacial Lake Warren beach deposit.
16.0	0.5	Junction with U.S. Route 20. Continue straight onto Fay Street. Climb onto glacial Lake Whittlesey beach deposit.
16.5	0.5	Junction with Webster Road. Turn left (east).

TOTAL MILES	MILES FROM LAST POINT	ROUTE DESCRIPTION
17.3	0.8	Pass Benchley Gravel Pit. Exposed at the face are glacial Lake Whittlesey beach deposits. The mine floor has been reclaimed to a vineyard, an excellent example of reclamation concurrent with mining. The floor was ripped to alleviate compaction, covered with subsoil, then topsoil, and seeded to perennial grasses and legumes. Grapes were planted 2 years later. Continue on Webster Road along Lake Whittlesey beach deposits. After junction with Highland Road, pass onto thin lacustrine sediments, over till, then back onto beach deposits.
18.5	1.2	Junction with Chautauqua County Route 380. Bear left on C.C. Route 380.
18.6	0.1	Junction with continuance of Webster Road. Bear right to continue on Webster Road along the beach ridge. On either side of the road, sporadic thin lacustrine silts overlie thin tills. Meltwater draining the young Cattaraugus Creek watershed flowed southwesterly across this area, removing most of the previously deposited sediments.
21.5	2.9	Junction with Ellicott Road. Continue east on Webster Road across a former meltwater channel and back onto the beach ridge.
23.4	1.9	Junction with Y intersection. Bear right. Continue on Webster Road across thin till.
23.6	0.2	Junction with Chautauqua Road. Continue straight on Webster Road across thin till.
24.5	0.9	Junction with Seymour Road. Continue straight on Webster Road across thicker till. Drop into Canadaway Creek Valley across outwash(?) or beach(?) deposit.
25.2	0.9	Junction with Chautauqua County Route 73. Continue straight on Webster Road.
25.5	0.1	Cross Canadaway Creek and park on left.

Stop 2: LAONA SILTSTONE MEMBER (description from Baird and Lash, 1990)

Laona Siltstone over Gowanda Shale at waterfall 200 feet southwest of car park at bridge (Overlook Stop Only). Note the sharp contrast between the conspicuously banded ("zebra" facies) of the Gowanda and the massive nature of the overlying Laona. The Laona and the higher Shumla Siltstone are believed to be gravity-flow units which record downslope movement of silt or fine sand into the anoxic to minimally dysoxic lower slope-basin setting recorded by the Gowanda-Westfield-Northwest shale members.

Return to vehicle(s). Continue east on Webster Road.

TOTAL MILES	MILES FROM LAST POINT	ROUTE DESCRIPTION
25.8	0.3	Junction with NYS Route 60. Turn right (south).
26.3	0.5	Junction with NYS Route 83. Turn left (east). Climb up from the Lake Erie Plain onto the Allegheny Plateau and cross the Lake Escarpment Moraine, partly correlative with the Valley Heads Moraine, between the previous turn and Arkwright. According to the Chautauqua County Soil Survey, the first 0.6 miles from the intersection crosses a mixture of tills and reglaciated outwash, lateral and recessional moraines.
29.9	3.6	Junction with Center Road at Arkwright. Continue straight (east) on NYS Route 83 along moraine. Drop into moraine-blocked valley and at Chicken Tavern Corners cross outwash valley.
31.7	1.8	Junction with C.C. Route 85 at Chicken Tavern Corners. Note reclaimed gravel pit on NW corner reverting to successional field since Chautauqua County DPW closed the site in the late 1980's. Continue on NYS Route 83. Cross hummocky valley filled with outwash, lake plain and till sediments. To the north (left) lies the Lake Escarpment/Valley Heads Moraine.
33.3	1.6	Junction with Zahm Road. Stay on NYS Route 83 and bend south along valley wall on outwash? or kame terrace? sands and gravels.
34.6	1.3	Climb onto till.
36.1	1.5	Junction with Chautauqua County Route 72 at Hamlet. Turn left (east) and continue on NYS Route 83 across a moraine (possibly an earlier position of the Valley Heads Moraine).
36.7	0.6	Cross onto delta deposit and drop onto west arm of lake dammed by the Valley Heads Moraine in the Conewango Creek Valley. Prior to glaciation, the west arm may have been a left bank tributary of the ancestral Allegheny River. The valley floor is now covered with outwash sand and gravel.

TOTAL MILES	MILES FROM LAST POINT	ROUTE DESCRIPTION
38.4	1.7	Junction with NYS Route 322 at Balcolm Corners. Continue straight onto NYS Route 322 at Balcolm Corners. Drop onto lacustrine sediments upon entering the Village of South Dayton.
40.6	2.2	Cross railroad tracks in the Village of South Dayton. The train station on the left appeared in the movie "Planes, Trains and Automobiles", starring Steve Martin and the late John Candy. Continue on NYS Route 322 across lacustrine sediments.
43.0	2.4	Junction with U.S. Route 62. Turn left (north) onto U.S. Route 62.
43.5	0.5	Pass Country Side Sand and Gravel, Inc. on right. Several lakes have resulted from excavation of (mostly) sand buried beneath up to 4 feet of lacustrine sediments. The deposit grades into finer material at 25-30 feet of depth. The valley floor elevation is approximately 1294 ft. asl. A deep ENE trending channel filled with coarser gravels and cobbles cuts across the site and bottoms near elevation 1250 ft. asl (Keith J. Scheetz, Country Side Sand & Gravel, Inc., personal communication), suggesting that the Persia Outlet of the young Cattaraugus Creek and glacially dammed lakes contributed the sediments, at least during early deposition. However, if the Persia Outlet, at elevation 1320 feet asl, drained with sufficient competence to carry coarse sediment more than three miles in a distinct channel, to where did the stream discharge? The lowest present outlet to the south is south of Kennedy at elevation 1250 ft. asl, more than 18 miles away. If the Country Side channel was deposited when the Perrysburg Outlet was exposed, why wasn't the Persia Outlet abandoned by the South Branch and Cattaraugus Creek in favor of the lower channel?
44.7	1.2	Climb up the edge of the silt moraine (Valley Heads?). The fine-grained composition of the moraine suggests that the deposit was bulldozed into place by advancing ice, instead of being deposited by meltwaters or stagnant ice.
45.3	0.6	Cross onto outwash sand and gravel. Pass through Markham, climb briefly onto till on the valley wall, then drop back onto kame terrace sand and gravel and pass through Dayton.

TOTAL MILES	MILES FROM LAST POINT	ROUTE DESCRIPTION
47.9	2.6	Cross railroad tracks in Dayton. Junction with NYS Route 353. Turn left. Stay on U.S. Route 62. Descend along tributary of Thatcher Brook through deeply dissected lacustrine sediments to Gowanda. Sporadic sand and gravel deposits capping the uplands on either side of the road may trace sequential meltwater channels through the Perrysburg Outlet and lower outlets to the northwest.
50.9	3.0	Confluence with Thatcher Brook on right. Extensive outwash sand and gravel deposits capping the upland east of the stream may result from progressive dissection and re-deposition of higher deltas built by Cattaraugus Creek and the South Branch as lower outlets were exposed, or may result from a later glacial re-advancement (Gowanda?). More work is needed. About 2200 feet south, a gas well penetrated 575 feet of glacial sediments before hitting bedrock.
52.4	1.5	Junction with NYS Route 39 and Water Street in Gowanda. Turn right (south) onto Water Street. If sufficient flow allows a white water raft trip, proceed ½ block to Zoar Valley Canoe and Rafting Company on the right and park. If not, continue on Water Street.
53.0	0.6	Junction with Broadway Road. Park in bare area on left, opposite Broadway Road. Walk about 700 feet north to Cattaraugus Creek.

Stop 3: GOWANDA SHALE TYPE LOCALITY, GRAND FINALE RAPID, CATTARAUGUS CREEK

The Gowanda Shale Type Locality crops out across the stream. Interbedded medium light gray to grayish-black shales, silty shales and thin to thick-bedded ripple-marked light gray silt stones characterize the Gowanda at this location. Many zones of calcareous concretions and septaria occur elsewhere within the Gowanda. Cattaraugus Creek cuts Grand Finale Rapid through a siltstone cap upstream, then through weak shales along a strong NW joint set. At flood water levels, a series of 10 to 15 foot high standing waves form between the base of the chute and the railroad bridge downstream. At medium water levels, the joint intersection at the base of the chute forms a challenging hole for white water rafters. A note of caution: at medium to high water levels, only experienced paddlers should attempt Grand Finale Rapid, unless accompanied by a NYS licensed guide or other experienced paddler.

The odor in the air comes from the buried tannery landfill adjacent to the stream. Currently on the U.S.E.P.A. Superfund List, plans are being developed to permanently remediate the site. A short walk upstream will reveal orange liquid leaching from the rocks and beneath the retaining wall.

Also evident along the stream is the gorge formation in microcosm. Joints parallel to streamflow are preferentially eroded, focussing water and further increasing erosion.

Return to vehicle(s). Proceed south on Broadway Road.

TOTAL MILES	MILES FROM LAST POINT	ROUTE DESCRIPTION
53.4	0.6	Pass Gernatt Asphalt Products, Inc. gravel pit on right, excavating Gowanda(?) Moraine outwash or meltwater channel deposits.
53.7	0.3	Junction with Point Peter Road. Turn left (east) onto Point Peter Road and drop into outwash covered proglacial lake floor.
54.2	0.5	Cattaraugus Creek Overlook alternative stop. Park in bare area. Follow a very narrow trail with no handholds to observe imminent breaching of a knife edge meander core immediately upstream of the confluence of Point Peter Brook and Cattaraugus Creek, a possible analogy for the origin of the Pyramid at the confluence of Cattaraugus Creek and the South Branch within the gorge. Gas Line, Turtle Rock and Shotgun Ledge Rapids are visible along Cattaraugus Creek from this location.
54.7	0.5	Junction with Valentine Flats Road, an alternative access road into Zoar Valley Gorge. A parking lot and trailhead occur at the end of the road about 4500 feet north, then east. A spectacular view of Valentine Flats exists about 1200 feet north of the parking lot. This field trip will not stop there. Continue straight on Point Peter Road and climb distal face of outwash delta deposit.
55.4	0.7	Point Peter Road gravel pit on left. Turn into pit.

Stop 4: POINT PETER ROAD GRAVEL PIT

Stratified sand and gravel beds, overlain by stony till, dip NW toward the former ice front. Were these sediments deposited as a delta when retreating ice allowed the South Branch to abandon the Persia Outlet and discharge into a proglacial lake draining past Perrysburg? Did a re-advancement, indicated by the overlying till, divert the South Branch to join Cattaraugus Creek across the head of the delta? If so, upon subsequent retreat, why didn't the South Branch drain south of the delta, instead of eroding through the head of the delta at a higher elevation?

Return to vehicle(s). Turn left (east) and continue on Point Peter Road.

TOTAL MILES	MILES FROM LAST POINT	ROUTE DESCRIPTION
55.5	0.1	Junction with Forty Road. Bear left onto Forty Road. Cross outwash slope and drop into South Branch Gorge. The road is quite steep. Note the first appearance of bedrock shortly after beginning the steep descent.
56.1	0.6	Parking Area at Forty Bridge. Prepare for a three mile hike. Your feet and lower legs will get wet.

Stop 5: SOUTH BRANCH GORGE

Welcome to Zoar Valley Gorge. The bedrock is probably the Westfield Shale Member of the Gowanda Formation, unless Bass Island Trend vertical displacement at depth, noted by VanTyne, et al. (1980), carried to the surface. If so, then the Gowanda Shale Member crops out in the gorge walls. The South Branch of Cattaraugus Creek flows north past the abutments of Forty Bridge, visible upon hiking to the stream, and joins the main branch about one mile downstream (Figure 3). A strong NW joint set is visible on both walls and in the streambed just downstream of the abutments. The same(?) joint set occurs upstream to the southeast, controlling the streambed, along the scarp of a massive landslide where the stream undermined the weakened right wall just below the big bend, and further upstream in the streambed at the confluence with a small waterfall on the right wall above the big bend. A similar strong NW joint set occurs roughly on strike to the northwest in Cattaraugus Creek where it controls the streambed for about 3700 feet from Redline Slop to Grand Finale Rapids.

Downstream, continuous N, then NE, joint sets bend back and forth through 20° of arc, periodically cut by NW joints. Weakly developed concretionary layers crop out in the streambed, partly coated with iron oxide.

Below a gravel bar, continuous NE joint sets control the streambed. About 3500 feet downstream of Forty Bridge, the stream drops through a siltstone package cut by strong NE joints, providing an excellent example of "stairstep stratigraphy". Joints and a very slight SE dip concentrate erosion along the bases of miniature cuestas, formed by thin siltstones and thicker shales, observable at very low water levels.

As the stream bends to the northwest, so do the joints in the streambed. Similarly, as the stream bends to the northeast at the next bend, so do the joints in the streambed. Fracture intensity increases approaching the confluence, with strong NE, NW, N and E joint sets intersecting with various cross-cutting relationships.

The gorge widens considerably at the confluence with Cattaraugus Creek. Downstream about 400 feet, a 35° pop-up fold occurs in the left bank at the top of Curly, Larry and Moe Rapid. The pop-up is interpreted as a surface expression of the Bass Island Trend. The rapid drops through a chute following a strong NW joint set, forming a playful wave train.

At the confluence lies Confluence Rapid, with a rock garden at the top above a siltstone caprock cut into a ledge by a 70° joint. The ledge has migrated upstream about 140 feet in the past seven years. Formerly a dangerous "keeper hydraulic", due to very strong back currents in the hole at the base of the ledge, the rapid is now an exciting cascade.

Upstream about 1500 feet lies Lunchstop Hole, another chute following a strong joint set, this time trending 65° to 95°. A series of holes within the chute provide a roller coaster ride.

Around the bend is Refrigerator Island Rapid, with a rock garden at the top above siltstone caps cut into ledges by 80°-90° joints. This rapid can be dangerous if a rafter drifts too far to the left and gets tangled up in the downed trees along the bank.

The siltstones capping Refrigerator Island, Lunchstop Hole and Confluence Rapids may be the same unit cut three times as the stream flows obsequently, subsequently and consequently through the reach. Projected from the type locality, the Laona Siltstone would crop out at the elevation of these rapids, if no structural displacement occurred. The Shumla Siltstone would crop out roughly 210 feet up the wall. A siltstone unit does occur at the projected elevation. Detailed mapping and petrographic analysis may resolve the Mystery of the Missing Laona.

Some questions:

1. Do the joints determine the locations of the rock gardens above the rapids by controlling the streambed, slowing down the water at bends where the stream intersects, then follows, a strong joint set?

2. Alternatively, do the rock gardens grow in classic pool and riffle mechanics and force lateral migration when the streambed crosses resistant siltstones until an intersecting joint set is exposed, encouraging downward erosion again?

Detailed mapping and surveying of the stream features, bedrock and structures may answer these and other questions. As time allows, the writer will pursue these investigations.

Please enjoy the 1.5 mile hike back to the vehicle(s).

Return to Gowanda. Bill's Lair, an excellent watering hole, is located next to Zoar Valley Canoe & Rafting Company. Delicious chinese food is available across the street. At the junction with U.S. Route 62 and NYS Route 39, turn left (west) but bear right onto NYS Route 39. Proceed about 18 miles to the junction with U.S. Route 20. Turn left (southwest) onto U.S. Route 20. Proceed 3.5 miles to Temple Street in Fredonia. Turn right (north) onto Temple Street. Proceed 0.7 miles to the Fredonia campus.

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4) Metzger, W.J., Tesmer, I. and Kirchgasser, W., 1974 Upper Devonian Stratigraphy of Chautauqua County, New York, Geol. W. NYS Guidebook, 46th Annual Meeting.

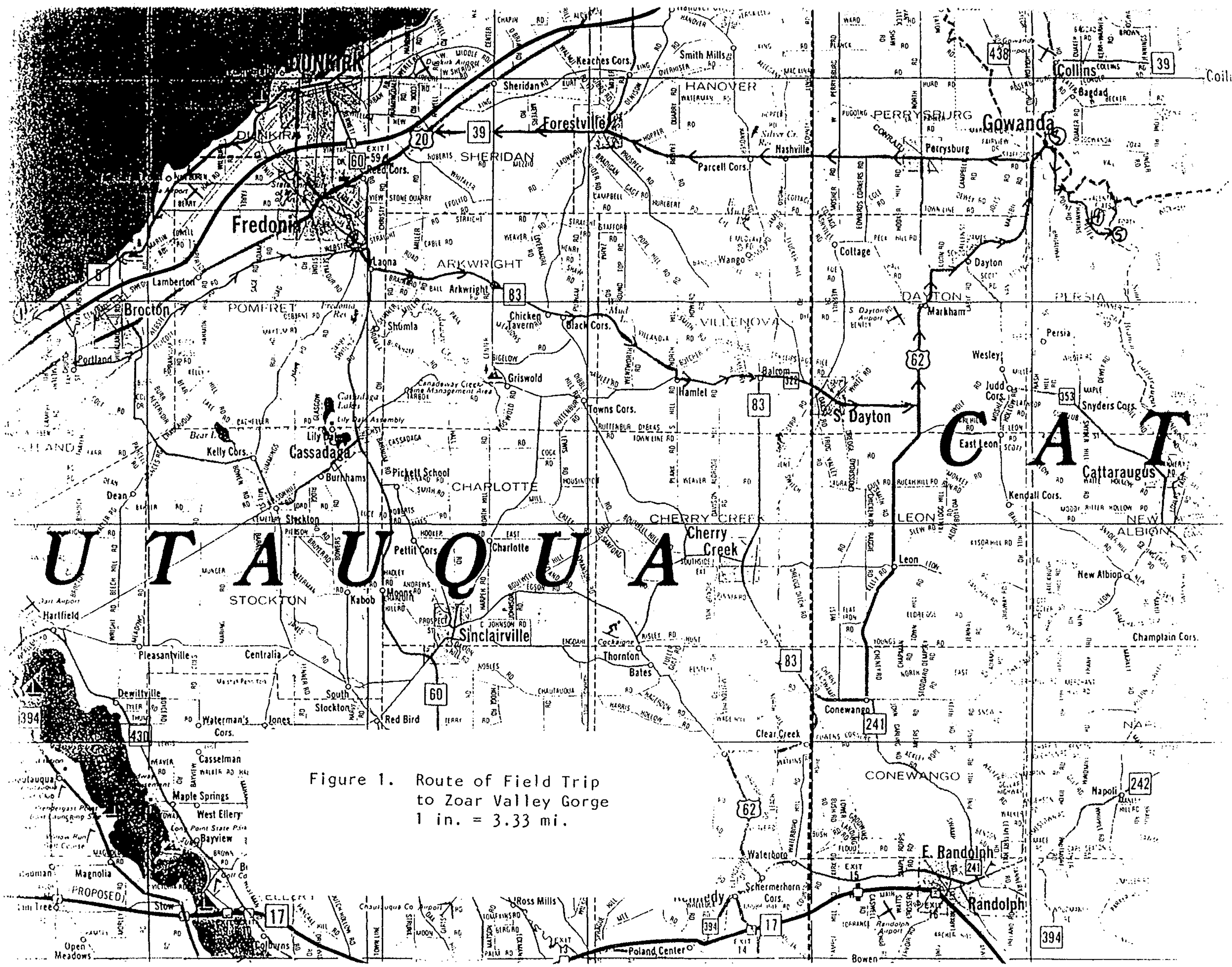
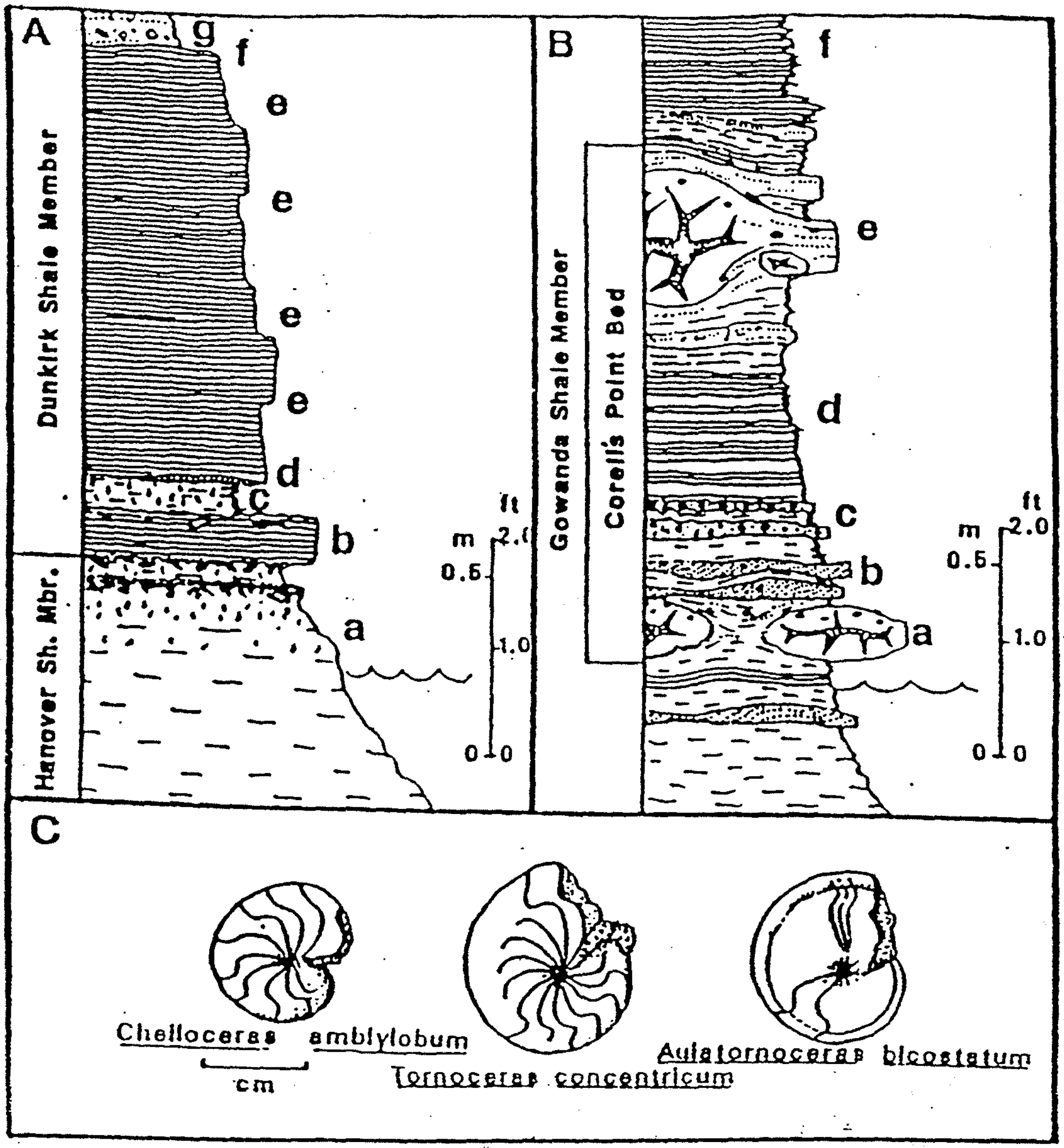
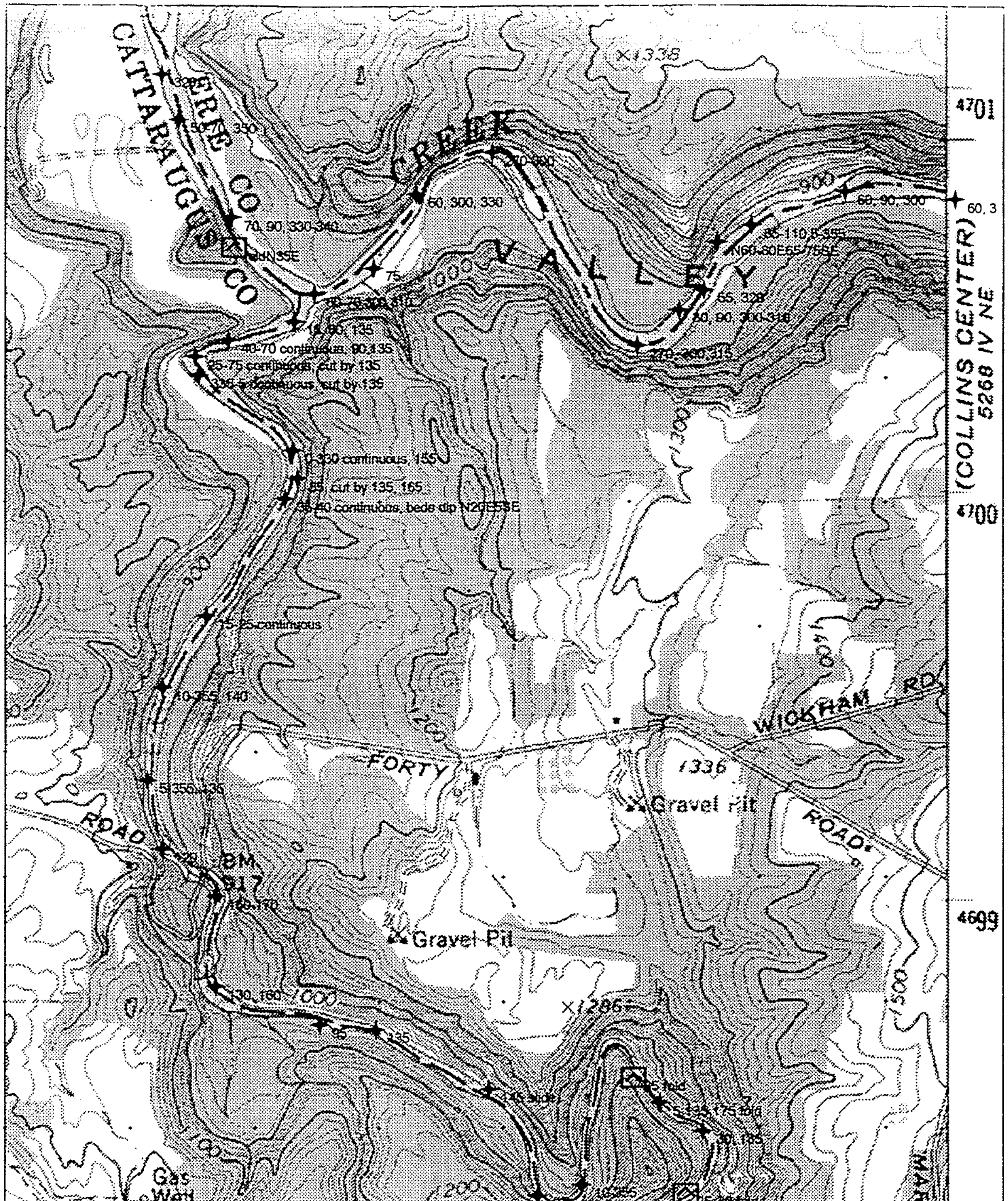


Figure 1. Route of Field Trip to Zoar Valley Gorge
1 in. = 3.33 mi.



Stratigraphic sections for the Point Gratiot and Corell's Point lake shore localities and key goniatite fossils from the Corell's Point Bed. A) Section at Point Gratiot . Lettered units include: a) intensely bioturbated grey-green mudstone; b) wood-and bone-bearing black shale bed; c) bioturbated grey-green mudstone bed; d) detrital pyrite lens along black shale-roofed discontinuity; e) laminated black shale; f) striated glacial scour contact; g) bedded glacial "till"; B) Section at Corell's Point (STOP1). Lettered units include: a) septarian concretions containing fossiliferous pyritic steinkerns; b) siltstone beds containing unfossiliferous pyrite nodules, c) bioturbated siltstone beds yielding numerous pyrite nodules, pyritic fossil steinkerns and non-pyritic fossils; d) interbedded black and grey-green shale ("zebra" facies); e) large septarian concretions with occasional pyritic steinkerns and abundant auloporid corals; f) black shale; C) Key zonal goniatites from Corell's Point Bed (After House, 1962, 1965; Kirchgasser, 1974).

Fig. 2. From Baird and Lash, in Lash, G.G. (ed) Field Trip Guidebook NYS Geol. Assoc. 62nd Annual Meeting, 1990.



Name: GOWANDA
Date: 8/17/99
Scale: 1 inch equals 1000 feet

Location: 042° 25' 55.4" N 078° 53' 16.8" W
Caption: Figure 3. Joint and Fold Orientations, Zoar Valley/South Branch Confluence, Cattaraugus Creek, NY