PREGLACIAL AND POSTGLACIAL DRAINAGE OF THE CENTRAL HUDSON VALLEY

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INTRODUCTION

The Problem

The preglacial drainage patterns of the mid-Hudson Valley have not been studied on a regional basis since the early nineteen-forties. These studies dealt with the meso- to macro-scale landscape features and their inferred relationships to Late Mesozoic and Early Cenozoic tectonism. They were limited by their reliance on the small scale and relatively crude maps and by the sparse subsurface information that were available at that time. The Holocene history of the area was only mentioned in passing in those studies because of the lack of information concerning Holocene features throughout the region.

Method

Abundant subsurface and surface data have been assembled during the nineteen seventies and eighties that can be used to illuminate the Late Cenozoic drainage history of the area. The modern topographic map and stereo airphoto data that are available for eastern New York State can be used in combination with Cultural Resource Surveys, archeological studies, engineering reports, historical records, and newspaper accounts to develop a Late Holocene through Recent geologic history of this region. I have used a sampling of such data to prepare this preliminary report on the Cenozoic drainage of the mid-Hudson Valley from Newburgh to Catskill. I have chosen selected sites west of the Hudson River to illustrate key points in this report.

Previous Studies

Several workers have noted peneplains in eastern New York State (Table 1). They have used these erosion surfaces to determine probable Cenozoic drainage systems. Ruedemann (1932) interpreted the regional erosion surfaces as implying westward drainage into the Mississippi Basin during the Early Cenozoic. The erosion surfaces are the Catskill, 2,500 ft, and Helderberg-Rensselaer peneplains. The Helderberg-Rensselaer surface has been correlated with either the Harrisburg Peneplain (Ruedemann, 1932) or the younger Kittatinny or Schooley Peneplain (Happ, 1938; Fenneman, 1938) of the central Appalachian Plateau.

Johnson (1931) surmised that the southeast-draining streams were established during the later stage of the development of the Schooley Peneplain. He noted that the streams presently flow across the major geologic structures and changes in lithology. He theorized that the streams originally flowed across a nearly-flat coastal plain developed on marine sediments that onlapped the older rocks from the present Atlantic coast to the Adirondacks. Streams were entrenched in their present courses during Middle Cenozoic uplift by superposition from the ancient coastal plain.

Ruedemann (1932), Mackin (1933), Fenneman (1938), and Happ (1938) agreed with Johnson's (1931) scenario. Mackin (1933), Fenneman (1938), and Happ (1938) correlated this superposition with the Schooley peneplain. All these workers attributed the absence of Cenozoic marine sediments inland from the present coastal plain to severe Late Cenozoic erosion.

Meyerhoff (1972) noted that the Cretaceous and Early Cenozoic marine rocks, presently preserved along the Atlantic coast, consist of near-shore facies. Consequently, it is unlikely that they extended inland for more than 30 miles. He attributed the present drainage to the normal processes of stream adjustment to structure. The Hudson Valley developed as the Cenozoic Hudson River worked its way westward, along the border of the arched New England thrust sheet. The Hudson undercut the base of the Appalachian Plateau along the Catskill Escarpment. This process was initiated during the Triassic, and was well underway by Schooley time (Meyerhoff, 1972).

Fairchild (1919), Stoller (1920), Ruedemann (1930), and Fenneman (1938) noted that the lowest peneplain in the Hudson Valley lies at an elevation of 200 ft, and is cut by a strath terrace that lies below sea level south of Troy, NY. All the present tributaries hang on the Hudson Gorge and enter the estuary of the Hudson across bedrock sills. Stoller (1920) and Simpson (1949) explained that the flat surface of the Albany Peneplain was more apparent than real; the lack of relief was caused by a thick blanket of glacial lake clays and sand. Deep preglacial valleys underlie the glacial sediment cover (Simpson, 1949; Davis and Dineen, 1969; Dineen and others, 1983).

Chadwick (1944) described the Hudson estuary in the vicinity of the Village of Catskill. He also described a series of abandoned stream terraces in the villages of Saugerties and Catskill that were formed as the Esopus Creek and Cats Kill cut down through the glacial lake deposits during post-glacial time.

Acknowledgements

This field trip is a progress report on projects that started twenty years ago when James F. Davis and I began a study of the bedrock topography of the Hudson Valley. I continued the study after Jim ascended to the post of State Geologist of New York in 1970. Eventually, I was able to determine the bedrock topography by compiling the logs of thousands of water wells gathered from interviews with home owners and drillers, supplimented by

STOP 11: Fawn's Leap (Fig. 10)

Fawn's Leap is a geological feature that was made famous by the Hudson River School painters. It is a waterfall that is cut into the top of the Kiskatom Formation (Fisher and others, 1970). It has formed where one of the major joint sets of the Appalachian Plateau crosses the Kaaterskill Clove (Chadwick, 1944). The Kiskatom Formation is apparently more resistant to erosion than the overlying rocks; the Clove has a distinct V-shaped notch below Fawn's Leap, with a wider, U-shaped valley above (Figs. 11b and c). The Kiskatom Formation also forms steeper slopes along the Catskill Escarpment (Fig. 11a). Seeps and springs are common in the inner gorge, many of the landslides are associated with the seeps (Bonafede, 1980; NYS Dept. of Transportation).

The stream gradient is 0.040 or 211 ft/mile from Fawn's Leap to the head of the alluvial fan. The Kaaters Kill has carved potholes, grooves and a plunge pool at the falls. Bars composed of very coarse-grained, imbricated boulders occur in the stream channel up-and down-stream from Fawn's Leap. Luanne Whitbeck (personal communication, Fall, 1983) noted small trees growing on the bars that were of approximately the same age (~10 to 15 years old). She suggested that the trees indicate that the bars were not active in 1983, and that the trees probably began growing during a drought when the stream flow was low. She also observed active landslides along the channel sides.

The floodplain is still quite thin in this reach. Large alluvial fans or cones have been deposited at the mouths of the high-gradient tributary streams in the Clove. Airphoto analysis and field work by Dineen, Whitbeck, and Lorie Dunn have documented abundant evidence for landslides, rockslides, earthfalls, and earthflows in this reach. Bonafede (1980) cites several nineteenth century maps that document similar features in the Clove.

STOP 12: Tannery Mill and East Hunter (Fig. 10)

This 0.5 to 0.75 mile hike follows the floodplain of the stream. The high embankment of Route 23a is on the right (north). Many examples of earthfalls can be seen in the channel banks. The exposures along the stream show that the floodplain deposits are 1 to 2 meters thick, and are composed of imbricated flat cobbles overlain by a thin veneer of silt. The gradient of the stream in the reach from Haines Falls to Fawn's Leap is 0.046, or 241 ft/mile.

We will pass a large (3 by 4 by 4 meters in diameter) boulder on the bank that was called "Rockefeller Rock" because of an inscription carved into the sandstone (Bonafede, 1980). That boulder had moved 5 to 10 cm away from the bank from 1979 to 1984 (Martha Costello, personal communication, Winter, 1985).

Our trek ends at the defunct East Hunter Tannery. This tannery complex and village were built in 1817 and abandoned by 1866 (Bonafede, 1980). The village is being buried by mass movements. The tannery shows abundant evidence for stream scour and deposition. The milldams that used to serve the tannery have been washed away.

Bonafede (1980) was not able to document the presence of artifacts that were more than 200 years old, in spite of an intensive search that included many shovel test pits. This observation suggests that the Clove gets "flushed out" regularly by the Kaaters Kill, a hypothesis that is strengthened by the evidence for mass wasting and flooding and by Route 23A's severe maintenance problems (NYS Department of Transportation).

The "horseshoe" where the road crosses the Kaaters Kill below Kaaterskill Falls is underlain by over 49 ft of red glacial till, based on NYS Dept. of Transportation test boring data. Landslides occur frequently in the area of the horseshoe (Frank Irving, personal communication, Summer, 1987).

<u>STOP</u> <u>13:</u> North Lake: Catskill Mountain House (Fig. 10)

The North and South Lake area is a State Park, and is the headwaters for the Kaaters Kill. It is developed on the dipslope of the Onteora Formation, the rock that forms the caprock of the Catskill Escarpment. Glacially striated conglomerates are exposed around the lakes. A major mountain inn served tourists in this area throughout the late nineteenth and early twentieth centuries (Bonafede, 1980). Its abandoned hulk burned about twenty years ago. The inn was built at the edge of the Catskill Escarpment.

The park is on the Helderberg Peneplain. The view from the Escarpment overlooks the Hoogeberg and Albany Peneplains. The Helderberg Plateau-Hamilton Hills are visible to the north. To the east lie the Taconic Mountains, and to the northeast the Rensselaer Plateau can be seen. The Rip Van Winkle and Kingston-Rhinecliff Bridges can also be seen from this vantage point.

The inn and the magnificent scenery lured many geologists into the North Lake area through the years. Darton (1895) suggested that the Kaaters Kill and the Platte Kill to the south have pirated the headwaters of the Schoharie Creek. These high-gradient streams had a major advantage over the Schoharie in that they had only to flow 7 to 10 miles to reach their base level at the Hudson, while the Schoharie waters had to flow 135 miles to reach the same point.

Rodgers (1987) wondered why the piracy took place as late as the Pleistocene. He suggested that the back-tilted edge of the Onteora Formation was so resistant to erosion that it impeded the headward extension of streams in the Hudson Valley for a long time. He also suggested that the Kaaterskill Clove was excavated by the stream in post-glacial time.

The NYS Department of Transportation drilled through 65 feet of compact till along the right-of-way of Route 23A from Intermann's Bridge to Haines Falls, so both the upper, wide valley of the Clove and the narrow gorge below Fawn's Leap are pre-Wisconsinan in age. The till must be studied in more detail to determine whether earlier glacial deposits are present.

hundreds of test- boring logs from the NYS Dept. of Transportation, the US Geological Survey, and various consulting firms. With the aid of Frank Angelloti, Steve Berger, Tom Costello, Pete Knightes, Paul Kopsick, and others, I was able to suppliment the drilling data with seismic refraction lines. The data permitted me to draft a series of 1:24,000 overlays, using a 50-foot contour interval, that show the topography of the bedrock surface in the Hudson Valley of eastern New York State. These maps are in the Open Files of the NYS Geological Survey.

I became intensely interested in the "overburden" of Holocene and Pleistocene deposits during the course of this study. My various studies of the glacial deposits are published elsewhere (Dineen, 1986; Dineen and Duskin, 1987). My fascination with Holocene studies are the result of collaboration with archeologists of the NYS Museum, particularly Patty Bonafede, Martey Costello, Bob Funk, Mark LoRusso, Phil Lord, and Beth Wellman. I have also been helped by Frank Irving and Ed Sees of the NYS Dept. of Transportation, who have shared their observations and data files with me. I wish to thank Bill Rogers and Bob Fakundiny of the NYSGS for their helpful criticism of this paper, and Jack Skiba of the NYSGS for drafting the illustrations.

Geography

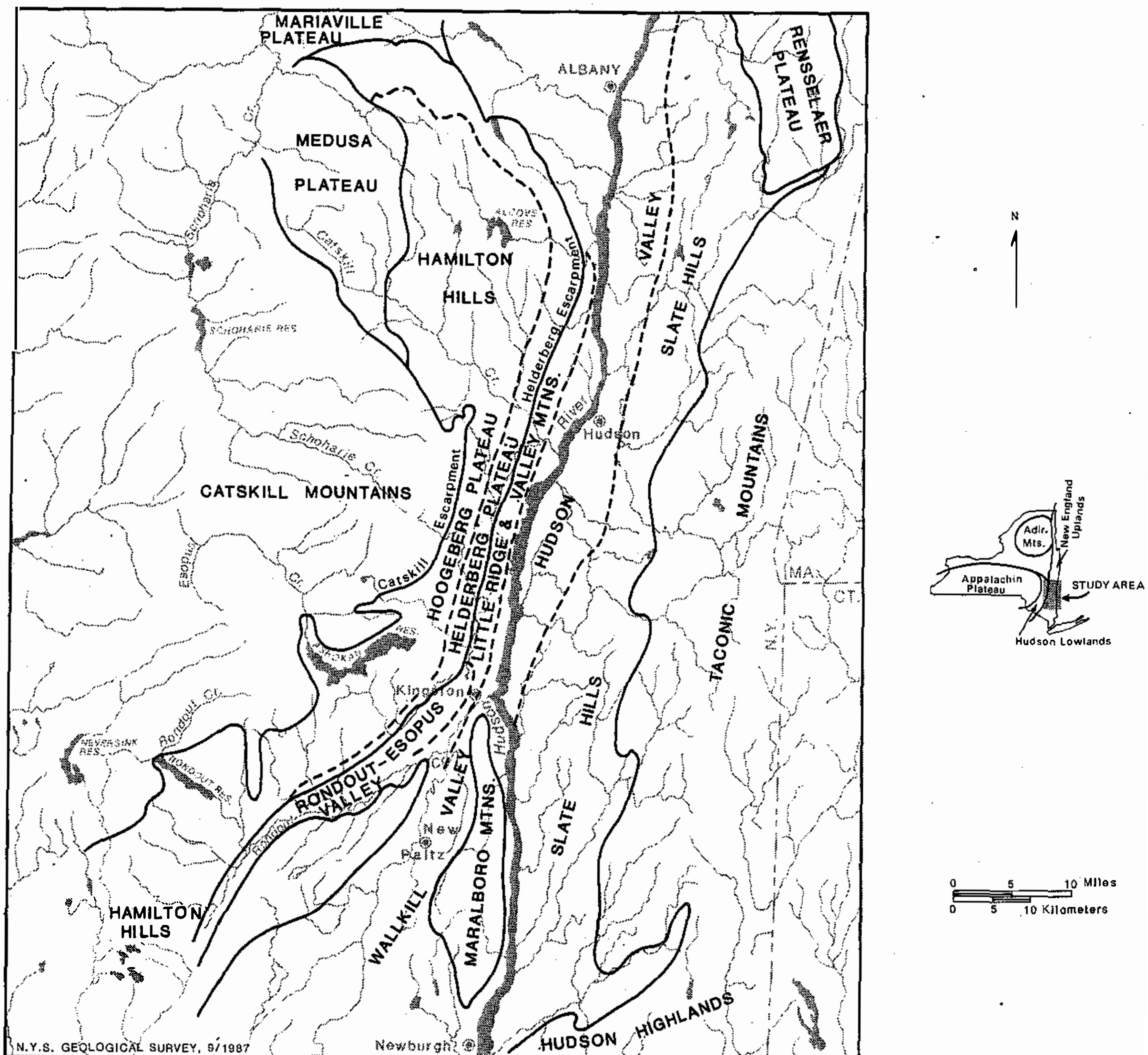
The mid-Hudson section of eastern New York State contains parts of three physiographic provinces. These provinces are the Appalachian Plateau, New England Uplands, and the Hudson Lowlands (Fig. 1; Cressy, 1966). The Appalachian Plateau is underlain by gently monoclinally folded marine and non-marine sedimentary rocks of Ordovician and Devonian age. The New England Uplands are metamorphosed sediments and igneous rocks of Cambrian and Ordovician age. The Hudson Lowlands are developed on highly folded and faulted sedimentary rocks of Ordovician age. The physiographic provinces can be divided into smaller sections on the basis of topography and underlying bedrock.

The Appalachian Plateau consists of the Catskill Mountains, Medusa plateau, Mariaville plateau, Helderberg Plateau, and the Hamilton Hills (Fig. 1). The plateaux are underlain by rocks that dip gently to the southwest. The Catskill Mountains are a deeply dissected cuesta that ranges in elevation from 2,000 to 4,500 feet. They are underlain by conglomerates and sandstones of the Upper Devonian Sonyea and Genesee Groups that are capped by the highly erosion-resistant Onteora Formation (Ruedemann, 1930; Fisher and others, 1970). The Medusa plateau rises to 2,000 feet, and is underlain by red sandstones of the Kiskatom Formation of Middle Devonian age (Fisher and others, 1970). The Mariaville plateau overlies gently southwest-dipping sandstones and shales of the Ordovician Schenectady Formation. It reaches elevations of 1,500 feet. The Helderberg Plateau is a cuesta underlain by Lower Devonian carbonates of the Onondaga Limestone and the Helderberg Group. It is moderately dissected, and attains elevations of 1,600 feet. The Hamilton Hills are also 1,600 feet high, and are underlain by Lower Devonian sandstones and shales of the Hamilton (Lower Sonyea) Group (Fisher and others, 1970). A prominent cliff, the Helderberg Escarpment, borders the Helderberg Plateau. A similar cliff, the Wall of Manitou or the Catskill Escarpment, borders the east and north edges of the Catskill Mountains.

The New England Upland can be divided into the Rensselaer Plateau, Taconic Mountains, and the Hudson Highlands (Fig. 1). The Rensselaer Plateau ranges in height from 1,600 to 900 feet. It is underlain by the relatively flat-lying Cambrian Rensselear Quartzite. The Taconic Mountains reach elevations of 2,000 feet and are underlain by intensely folded Cambrian and Ordovician phyllites, marbles, schists, and slates (Fisher and others, 1970). The Hudson Highlands are underlain by highly metamorphosed igneous and sedimentary rocks of Precambrian through Devonian age. The Highlands are 1,100 to 1,600 feet high.

The Hudson Lowlands are a continuation of the Ridge and Valley Physiographic Province (Fenneman, 1938), and include the Rondout-Esopus Valley, Wallkill Valley, Hudson Gorge, Little Ridge and Valley, Slate Hills, Shawangunk Mountains, and Marlboro Mountains (Fig. 1). Homoclinally-folded limestones of the Devonian Helderberg Group underlie the Rondout-Esopus Valley (Fisher and others, 1970). The Wallkill Valley is carved into a belt of intensely folded shales of the Ordovician Martinsburg Formation (Waines and others, 1983). The Hudson Gorge follows the tightly folded Normanskill Group of sandstones and shales of Ordovician age (Fisher and others, 1970). These lowlands lie below the 600 foot contour line. The Little Ridge and Valley is a range of low longitudinal ridges composed of highly folded limestones and shales of the Devonian Onondaga, Marcellus, and Bakoven Formations, and the Helderberg Group (Fenneman, 1938; Chadwick, 1944). This range of hills attains heights of 300 feet. The Slate Hills are an assemblage of low, rounded hills, with heights of 600 feet. They have many outcrops of the moderately metamorphosed Cambrian slates of the Nassau Formation (Fenneman, 1938). The southern extension of the Slate Hills are underlain by Cambrian through Ordovician carbonates of the Wappinger Group (Fisher and Warthin, 1976). The Shawangunk Mountains are a hogback of steeply-dipping beds of the Silurian Shawangunk Quartzite. The white cliffs reach elevations of 2,000 feet. The Marlboro Mountains consist of folded sandstones of the Ordovician Quassaic Formation (Waines and others, 1983) that reach elevations of 700 feet.

The physiographic provinces were molded by weathering and fluvial processes during the Cenozoic era. All of the provinces have been modified by glacial and postglacial erosion and deposition.



Adopted from Fenneman, 1938; Chadwick, 1944; Cressy, 1966

Figure 1. Physiographic Provinces

PREGLACIAL DRAINAGE

Peneplains

Large, nearly planar erosion surfaces developed during long periods of weathering and erosion in the Cenozoic era. These nearly flat to gently undulating plains are peneplains or etchplains. Several have been mapped or described in the mid-Hudson region (Campbell, 1903; Ruedemann, 1930 and 1932; Fenneman, 1938; Happ, 1938; Chadwick, 1944). These erosion surfaces are the Catskill, Helderberg-Rensselaer, and Albany peneplains (Table 1 and Ruedemann, 1930). Each peneplain was developed during long periods of relatively stable base-level control. The peneplains cut across the geologic structure and the bedrock contacts. Monadnocks of more resistant rocks locally rise above the individual peneplains. The development of each peneplain was interrupted by subsequent uplift.

These peneplain surfaces were imperfectly developed or preserved. Development of a nearly flat surface that is graded to a base-level requires that the base-level be stable for millions of years. Thus episodes of uplift can interrupt the peneplanation process. The resulting uplifted surface will preserve features consistant with that peneplain's "maturity."

Erosion surface first form adjacent to the major streams, and then broaden by backwasting of the nearby upland surfaces. Monadnocks form in areas where the bedrock is exceptionally resistant to erosion or along the drainage basin divides. Thus, the incipient peneplain first develop as "strath terraces" (fluvially eroded bedrock surfaces) along rivers and later extend across the entire landscape. This process requires that the peneplains develop by progressive spreading from the trunk streams into the adjacent uplands along upland tributary stream valleys. The peneplain will thereby be most "mature" near the coast, and will exhibit "youthful" strath terraces in nearby uplands.

Multiple episodes of uplift and base-level stability result in the development and preservation of multiple peneplain surfaces. The older peneplains are dissected during the formation of younger peneplains. Frequently the older peneplains will be preserved as accordant elevations of mountain tops or hilltops, windgaps, or as bedrock terraces along the valley sides.

Six erosion surfaces can be mapped in the mid-Hudson Valley. The oldest is the Catskill Peneplain (Table 1 and Fig.2). It was described by Ruedemann (1930) as a highly dissected, 4,000-ft surface that is preserved as accordant mountain tops in the high peaks of the Catskill, Adirondack, and Taconic Mountains. It slopes towards the southwest (see Fig. 6 in Coates, 1974). The Catskill Peneplain is deeply embayed by the headwaters of the Schoharie Creek. These headwater valleys are extentions of the next-youngest erosion surface- the Helderberg Peneplain (Chadwick, 1944).

TABLE 1 PENEPLAINS OF THE MID-HUDSON VALLEY

WORKER: Campbell, 1903	Ruedemann, 1930,1932	Fenneman, 1938	Happ, 1938	Chadwick, 1944	Dineen, this report
PENEPLAIN/ elevation in feet/ regional correlation :					
-	Catskill	-	High Catskills	-	Catskill
-	4,000	-	4,000		4,000
-	-	-	-	-	-
-	-	-	-	-	-
-	2,500	-	-	-	-
-	Kittatinny	-	-	-	-
-	Helderberg-Rennselaer Plateau	-	"2,000 ft Surface"	Helderberg	Helderberg
-	2,000 to 1,600	2,000 to 1,400	2,000	2,000	1,200? to 2,000
-	Harrisburg	Kittatinny (Schooley)	Kittatinny (Schooley)	-	-
-	-	-	Monticello	-	Monticello
-	-	-	1,200 to 1,700	-	1,200 to 1,700
-	-	-	Hamilton Bench	-	Ashokan
-	-	-	900	-	700 to 1,100
-	-	-	Harrisburg (Chambersburg)	-	-
-	-	-	-	Hoogeberg	Hoogeberg
-	-	500 to 400	600 to 500	600 to 400	600 to 400
-	-	Harrisburg	Somerville	-	-
-	Albany	-	-	Kalkberg	Albany
300 to 100	300 to 200	400 to 200	-	400 to 200	400 to 200
Somerville	-	Somerville	-	-	-
-	"Inner Gorge"	"Inner Gorge"	-	-	Castleton
-	-100	100 to -700	-	-	125 to -25
-	-	-	-	-	-

The Helderberg Peneplain is highly dissected but widely preserved throughout the Hudson Valley (Table 1 and Fig. 2). It is best developed in the Helderberg and Rensselaer Plateaus and along the eastern edge of the Catskill Plateau (Fig. 3). It is the Helderberg-Rensselaer Peneplain of Ruedemann (1930 and 1932), the "2,000-ft surface" of Happ (1938), and the Helderberg Peneplain of Chadwick (1944), and ranges in elevation from 1,200(?) to 2,000 ft, sloping northward and southwestward off the Appalachian Plateau (see Fig. 6 in Coates, 1974) and south in the lower Hudson Valley (Figs. 3a to c). The Helderberg Peneplain is deeply dissected by valleys that are part of the modern drainage network and is best developed around the High Peaks of the Catskill Mountains (Fig. 2; see also Fig. 6 in Coates, 1974).

Happ (1938) described the Monticello Peneplain as a late stage of the "2,000-ft surface." He mapped this feature in the Wall Kill and Delaware Valleys. It is developed at elevations from 1,300 to 1,700 ft and blends into the Helderberg Peneplain to the north and southeast (Happ, 1938). The Monticello Peneplain might have developed as a response to 300 to 400 ft of uplift in late Schooley time (Happ, 1938). It can be considered an immature or incipient peneplain that post-dates the Helderberg Peneplain, and can be traced from the Rensselaer Plateau to the Hudson Highlands (Figs. 2 and 3). It blends into the Helderberg Peneplain in many places (note the overlap in elevations in Table 1). It is seperated from the Helderberg Peneplain by sharp escarpments in the Medusa and Helderberg Plateaus (Fig. 2 and 3).

The Hamilton Bench is a narrow bedrock terrace developed on the Hamilton (Sonyea) Group in the Monticello area (Table 1; Happ, 1938). The surface is at an elevation of 900 ft near Monticello and can be traced to the northeast, where it rises from 700 to 1,200 ft (Figs. 2 and 3a to c). I am renaming this surface the Ashokan Peneplain because it is best developed in the Ashokan Reservoir area (Figs. 2 and 3c). It can be traced north to the base of the Rensselaer Plateau (Fig. 3a). This peneplain grades into the Monticello surface on the dipslopes of the Hamilton Hills (Fig. 2).

Chadwick (1944) classified the 600 to 400 ft bedrock terrace that lies at the foot of the Catskill Mountains as a piedmont. It cross-cuts the bedrock structure in this area and makes up the low plateau known locally as the Hoogeberg (Fig. 3b). This surface can be traced into the Wall Kill Valley to the Clintondale area (Fig. 3c). It can be traced north into the Cats Kill Valley (Fig. 2), and up the Hudson Valley to the bases of the Helderberg and Rensselaer Plateaus (Fig. 3a). It is named the Hoogeberg Strath Terrace in this report.

The Albany Peneplain is an incipient peneplain developed adjacent to the Hudson River from Glens Falls, NY to Newburgh, NY (Ruedemann, 1930). It is widest in the Albany area and lies between elevations of 200 and 400 ft (Fenneman, 1938; Ruedemann, 1930). Several immature south-dipping strath terraces in this

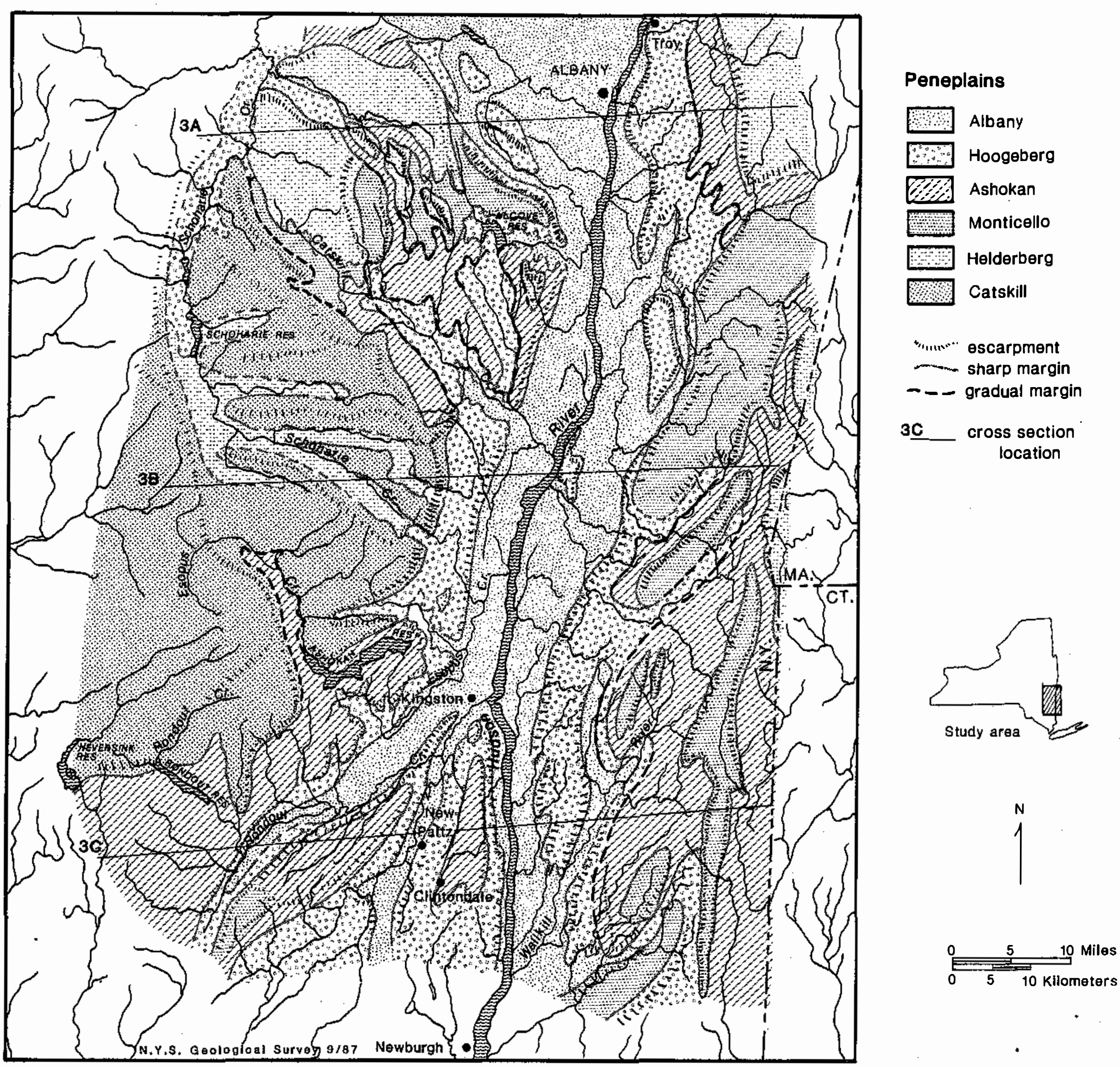


Figure 2. Peneplains

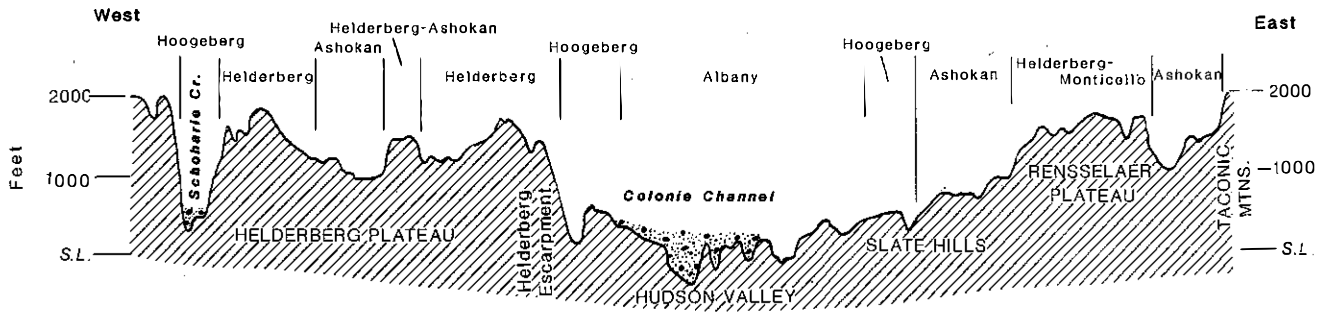
elevation range can be traced in the Hudson Valley near Albany (Fig. 3a; Dineen and others, 1983). The two stongest terraces are the Glenmont and Albany Strath Terraces. The Glenville Strath slopes south from 380 to 370 ft and has a gradient of 0.5 ft/mi. The Albany Strath ranges from 240 to 210 ft in elevation and has a gradient of 1.25 ft/mi. The Albany Peneplain or Strath Terraces can be traced from Albany to Newburgh (Figs. 2 and 3).

The Albany Peneplain is deeply incised by the "inner gorge" of the Hudson (Stoller, 1920; Ruedemann, 1930). The "inner gorge" was carved during the Late Cenozoic and is part of the preglacial drainage network (Table 1 and Fig. 4).

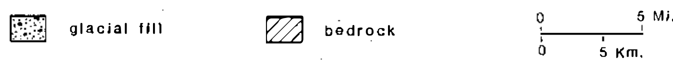
Preglacial Streams

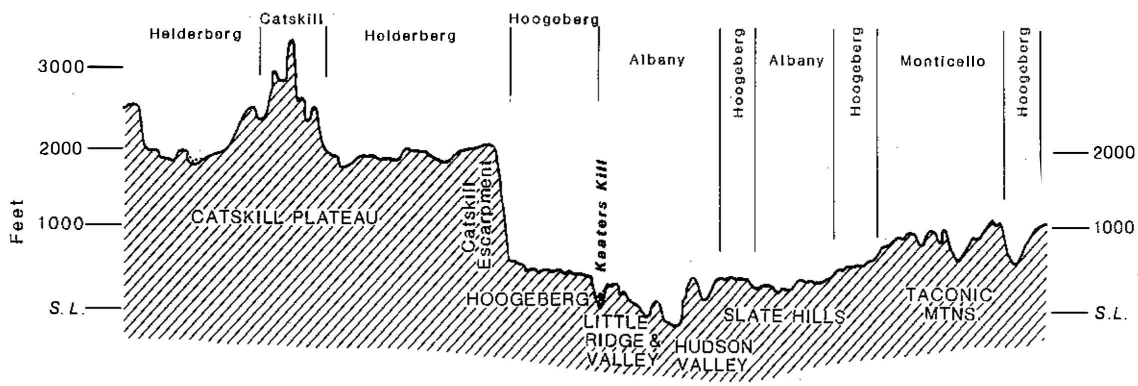
The preglacial drainage pattern of the mid-Hudson Valley can be deduced from the topography of the bedrock surface. Deep valleys underlie the glacial deposits of the region. The connections between the valleys include water gaps (a pass through a rock ridge that a stream drains through), wind gaps (a sag or pass through a ridge that once carried a stream), and dirt gaps (a buried pass or sag in a rock ridge that once carried a stream). Thus, the preglacial drainage of the region can be mapped by connecting the buried valleys using simple rules, such as "water flows downhill" and "the preglacial streams were adjusted to bedrock structure." Deep scouring of lowland areas by glacial ice complicates the interpretation of preglacial drainage somewhat (Kemp, 1915; Dineen and others, 1983). The preglacial drainage map (Fig. 4) traces the <u>late</u> preglacial drainage. The Albany Peneplain had been deeply etched by rejuvenated rivers during the Late Pliocene or Early Pleistocene. Now-buried waterfalls that were paleo-knickpoints are found in the Albany region (Fig. 4; Dineen and others, 1983).

The preglacial river network of the Hudson Valley had a strongly-developed trellis to rectangular drainage pattern (Fig. 4). The pattern in the Hudson Lowlands was influenced by the distribution of belts of folded and faulted shale, limestone, sandstone, and chert. The chert and sandstone underlie the interfluves, while shale underlies the valleys or river channels (Davis and Dineen, 1969). The trunk stream at this time was the Colonie Channel (Simpson, 1949), a buried valley that extends from Coeymans to Glens Falls, NY (Dineen and others, 1983). The present Hudson River was a tributary to the Colonie that rose in the Batten Kill- Hoosic River drainage in the Taconic Mountains. The Batten Kill-Hoosic channel hangs on the Colonie Channel at Castleton (Figs. 5a, 5b and 6). The Castleton Strath Terrace was developed in the Batten Kill-Hoosic channel north of that confluence (Dineen and others, 1983). It lies between elevations of 125 and -25 ft in the Albany area (Dineen and others, 1983), and has a gradient of 1 ft/mi to the south. It can be traced south to the Kingston-Rhinecliff Bridge, where it reaches an elevation of -80 ft (Fig. 6). This strath terrace is incised by a narrow gorge that is carved to a depth of -100 ft at Castleton (Figs. 5a and 6). The Colonie Channel becomes the Hudson channel

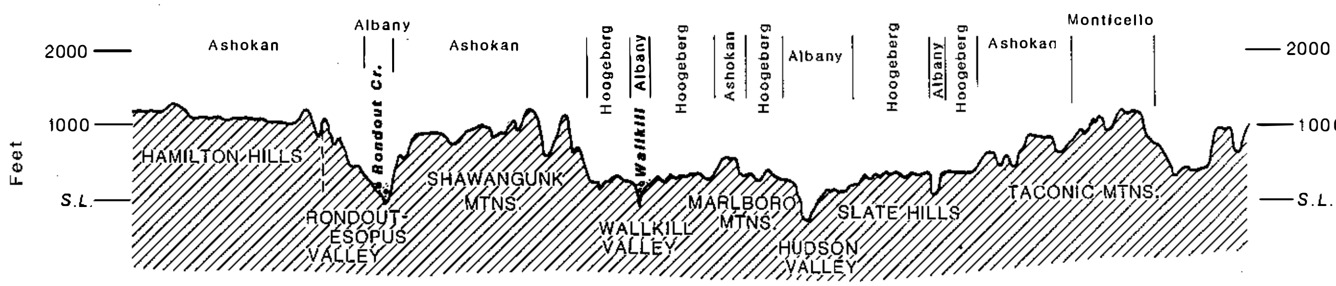


3A. ALBANY





3B. CATSKILL



3C. NEW PALTZ

Figure 3.
Physiographic Provinces Cross Sections

south of Coeymans (Fig. 4), and falls to an elevation of -290 ft at the Newburgh-Beacon Bridge (Fig. 5f).

The tributary streams developed a longitudinal drainage pattern that followed the strike of zones of shale, major joint sets, or fault zones. Transverse streams cut across the resistant rock ridges and connected these longitudinal streams with the trunk streams. The drainage pattern that developed along the margin of the Appalachian Plateau was an especially well-developed trellis drainage pattern (Fig. 4). The longer stream segments tended to follow shale belts, while their tributaries were dip-slope streams developed on the major joint sets (Chadwick, 1944).

The Slate Hills were also drained by a longitudinal drainage system that developed parallel to the axes of folded shale belts and along the edges of the Taconic thrust sheets (Fig. 4). The longitudinal drainage in the southern section of the Slate Hills was controlled by the strike of Lower Paleozoic carbonates (Fisher and Warthin, 1976). The drainage pattern of the Wall Kill Valley was controlled by the fold axes in the Martinsburg Shales. The streams in the Rondout-Esopus Valley and the Little Ridge and Valley were controlled by steeply-dipping beds of shales. The adjacent limestones formed ridges. Note that the limestones formed ridges in the Little Ridge and Valley area and formed the caprock of the Helderberg Escarpment, while limestones and dolostones underlie the valleys in the southern section of the Slate Hills. The moderately metamorphosed shales of the Slate Hills were more resistant to erosion than the unmetamorphosed shales in the Little Ridge and Valley and the Helderberg Plateau.

The phyllites of the Taconic section of the New England Uplands were very resistant to erosion. Most of the longitudinal valleys in this section were underlain by marble (Fig. 4; Fenneman, 1938). The valleys in the Hudson Highlands tended to be underlain by either marble or fault zones (Fisher and others, 1970).

HOLOCENE

Sea level was significantly lower during the glacial periods than it is at Present. Much of the Earth's water was "locked up" in the retreating glaciers during late glacial time. This lowered the base level of the streams in the mid-Hudson Valley and allowed them to deeply entrench the glacial deposits that clogged the Hudson Gorge and its tributaries. Sea level was 180 feet below its present level 10,200 years ago (Wiess, 1974). It had risen to 45 feet below present level by 8,000 yr B.P., and was 12 feet below by 4,000 yr B.P. (Averill and others, 1980; W. S. Newman, personal communication, Spring, 1986). The Hudson is now an estuary from the New York Harbor to Troy, NY.

Bridge borings indicate that the Hudson had scoured an inner gorge to 30 ft BSL in the Castleton area (Figs. 5 and 6) and to 120 ft. BSL near Poughkeepsie (Fig. 5e and 6). The tributaries of the Hudson eroded at least 150 feet of glacial sediment out of

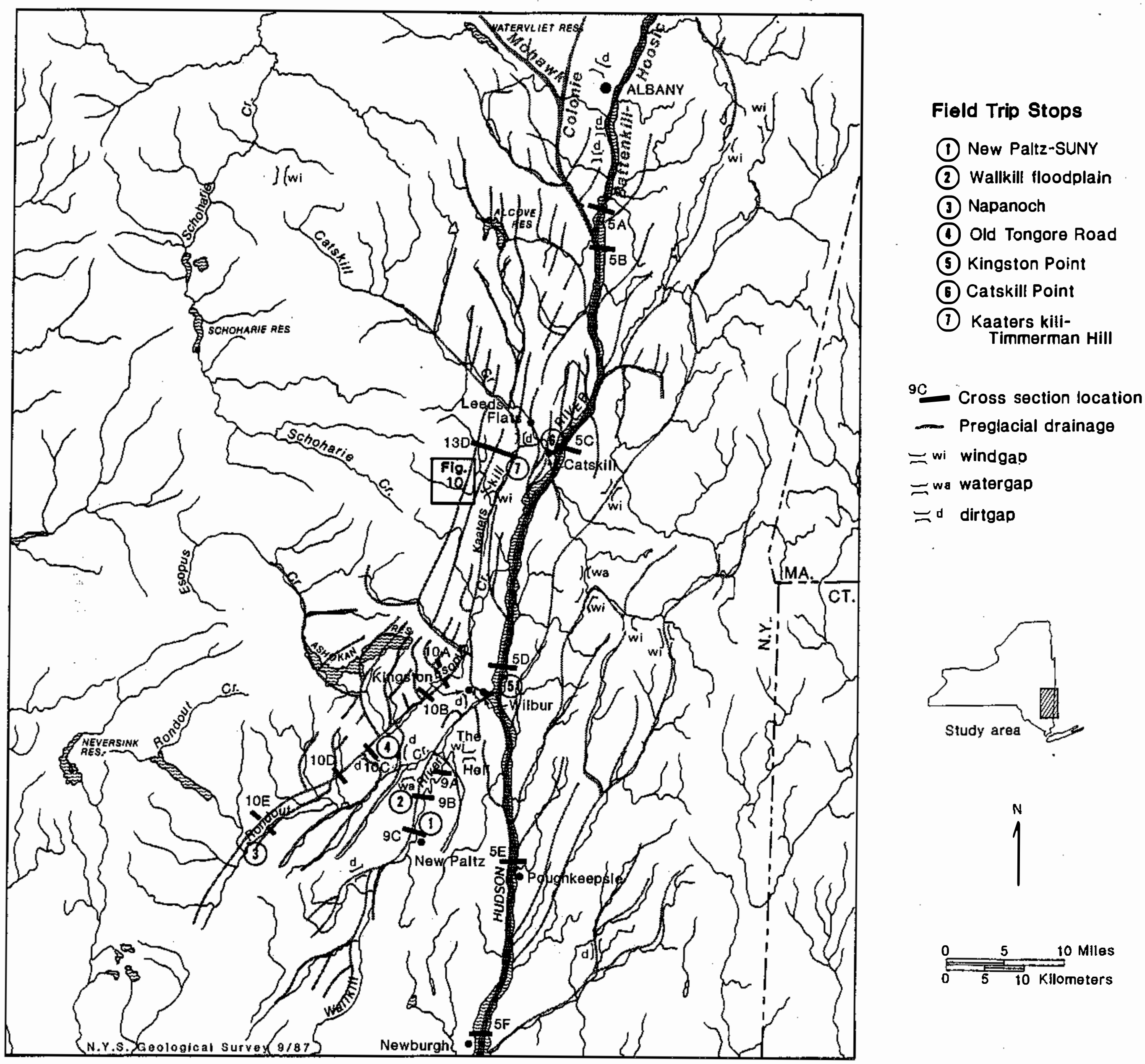


Figure 4. Late Preglacial Drainage & Field Trip Stops

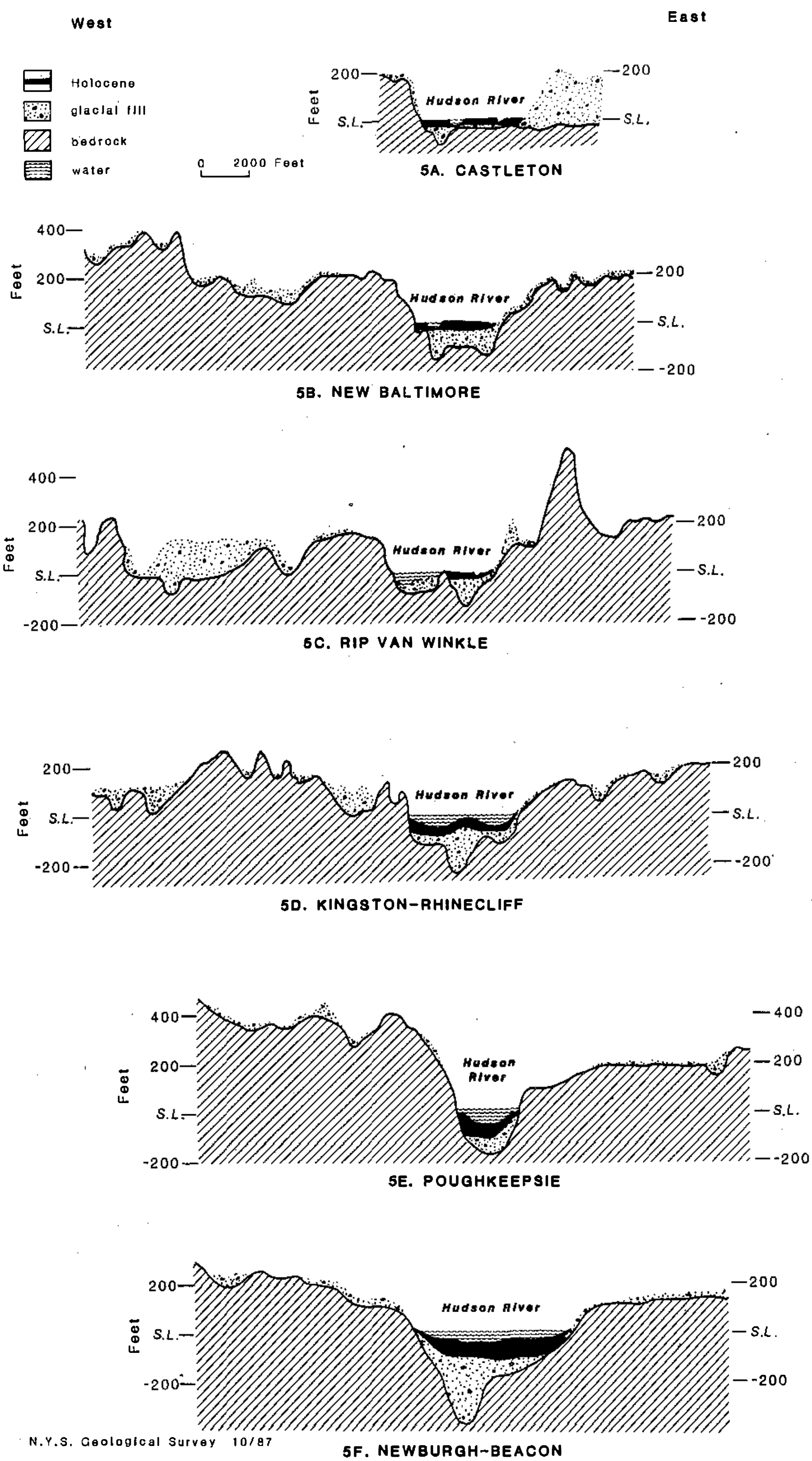


Figure 5.
Hudson River Cross Sections

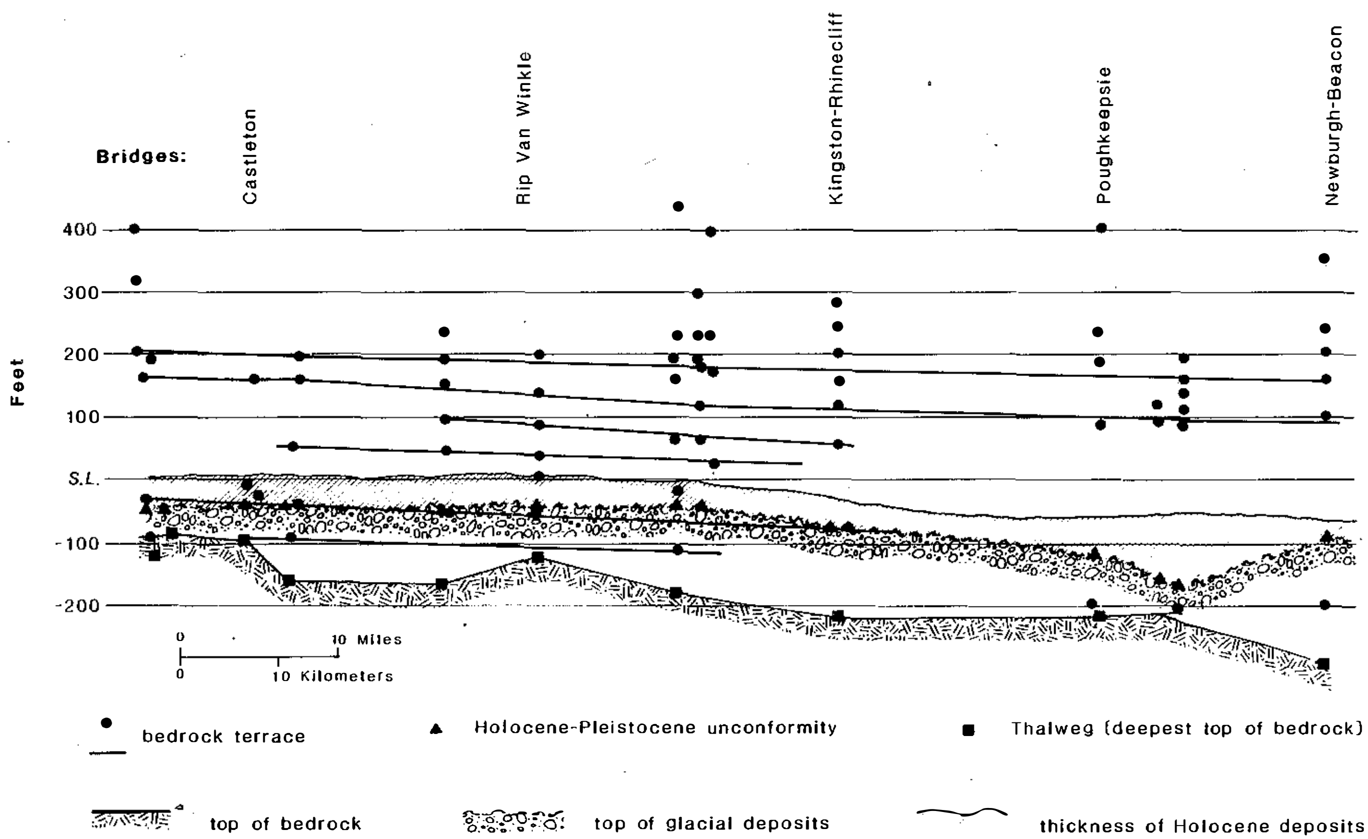


Figure 6.

Longitudinal Section of the Hudson Gorge from Albany to the Newburgh-Beacon Bridge

their lower valleys during Holocene time (Fig. 6; Dineen and Duskin, 1987). Organic-rich silty fine sands have filled the Hudson and its tributary confluences as they were flooded with tidal waters within the past 4,000 years. Many of the tributary streams have deposited large Holocene deltas in the Hudson, these deltas are drowned south of Saugerties (Fig. 7). Rogers Island, under the Rip Van Winkle Bridge, is the southernmost extension of the Hudson River's Holocene delta (Figs. 5c and 7). The Hudson's floodplain and delta is at least 8,000 to 10,000 years old near Albany, based on Spruce Pollen-bearing floodplain deposits that was encountered in test borings (personal communication, Mr. Donald Lewis-NYS Biological Survey, Summer, 1985).

The tributaries of the Hudson River still exhibit a trellis drainage pattern in the upland areas (Fig. 7). Nevertheless, these tributaries form a dendritic drainage pattern where they cross the wide glacial lake plains in the Hudson Lowlands. The deposits of lake clay are significantly thinner and more restricted in the southern Hudson Lowlands and stream pattern is therefore more trellised (Fig. 7).

The tributary streams tend to meander across wide floodplains that are developed on the lake clays. The broad floodplains of the Wappinger Creek, Wall Kill, Rondout Creek, Kaaters Kill, Cats Kill, Normans Kill, and the Kinderhook Creek are all developed upstream from bedrock-defended rapids. Downstream from the rocky knickpoints, they flow in narrow, steep-walled valleys with perched (abandoned) meanders along the valley walls. Almost all of the Hudson's tributaries fall across rock ridges as they reach the Hudson. The waterfalls are developed on the edge of the Albany Peneplain (Stoller, 1920). The floodplain deposits are coarse-grained at their base and tend to become finer-grained towards their top (Dineen and Duskin, 1987).

Large alluvial fans have been deposited at the base of the Catskill Escarpment at West Shokan, Bearsville, West Saugerties, and Palenville (Fig. 7). These fans have fresh surfaces with poor soil development and many abandoned and active braided stream channels. Some have deeply incised their heads and have been reactivated (West Saugerties). Locally they dammed small proglacial lakes, as at Palenville (Dineen, 1986). Thus, they started forming during the Late Pleistocene, but are probably still active. Similar fans lie along the base of the Rensselaer Plateau at Hoags Corners and Poestenkill and at the base of the Hoogeberg Peneplain at Napanoch and Tongore Road (Fig. 7).

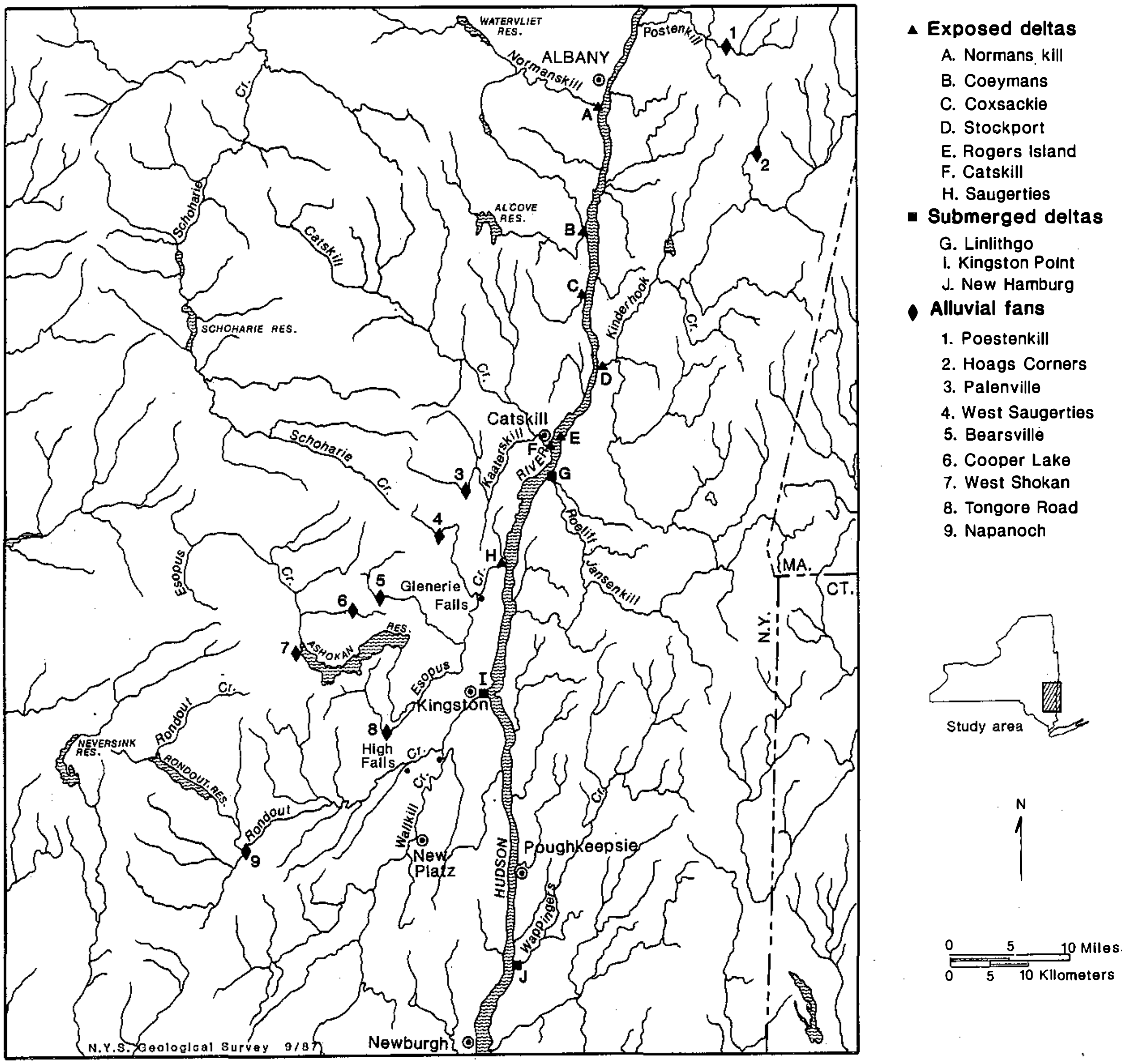


Figure 7. Modern Drainage

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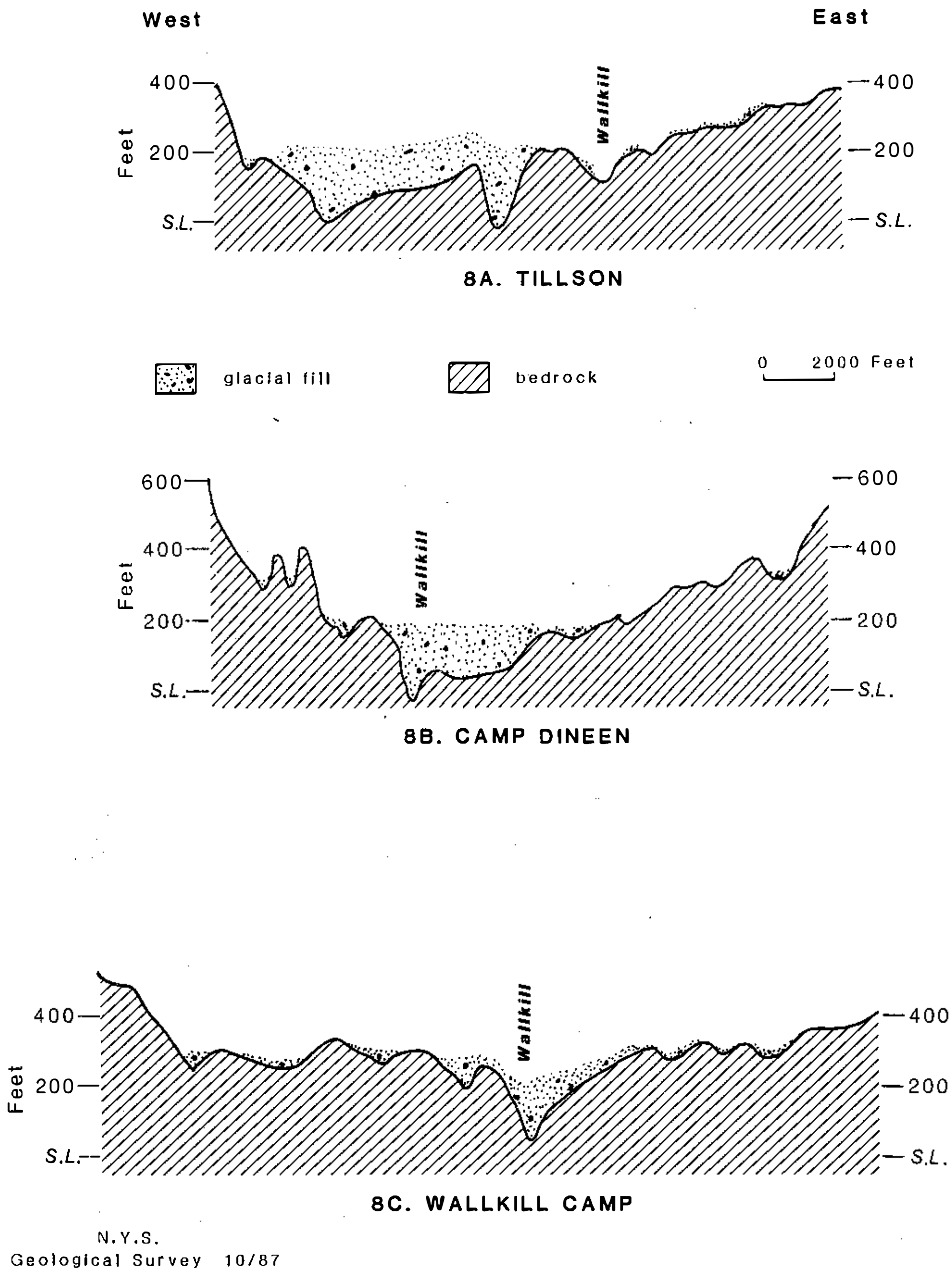

Figure 8.
Wallkill Cross Sections

FIELD STOPS-NYSGA 1987 FIELD TRIP

START: SUNY at New Paltz (Fig. 4)

STOP 1: New Paltz Bedrock Terrace- SUNY at New Paltz Parking Lot Clintondale, Gardiner, and Rosendale 7-1/2 minute quads.

The section of the Wall Kill Valley near the State University College contains a sequence of strath terraces that range in elevation from the Hoogeberg to the Albany Peneplains (Figs. 3c and 8c). Several of these terraces are mappable in the lower Wall Kill Valley. Dissected and glacially scoured remnants of the Hoogeberg Peneplain occur along the western edge of the Marlboro Mountains. This surface is sharply truncated at Clintondale by a 400- to 420-foot surface that can be traced southwest to the State line. The 400- to 420-ft terrace is cut, in turn, by a 340- to 360-ft terrace. This terrace extends through the windgap in the Marlboro Mts known as The Hell (Figs. 2, 4 and 8a). A third terrace lies at 280 to 300 ft (Figs. 8a, b, c). The SUNY at New Paltz campus is built on this terrace. The 280- to 300-ft terrace can not be traced south of Walden. It extends north into the Hudson Valley and west into the upper Rondout Valley.

The Ashokan Peneplain is preserved by the ridge line of the Shawangunk Mts (Figs. 2 and 3c). Monadnocks of the Helderberg and Monticello Peneplains remain as high points along the Shawangunks.

STOP 2: Wall Kill Floodplain: intersection of Mountain Rest and Springtown Roads (Fig. 4)
Rosendale, Clintondale, Gardiner, and Mohonk Lake 7-1/2 minute quads.

The reach of the Wall Kill downstream from New Paltz is underlain by 200 ft of glacial-lacustrine deposits. These sediments fill a gorge that was cut into the Albany Peneplain (Figs. 6 and 8) during preglacial or interglacial time. The gorge narrows and becomes shallower to the south, and disappears between Wallkill Camp and Wallkill Village (Figs. 8b and c). The gorge underlies the Tillson area (Fig. 8a) and passes west of the present Rondout Creek through the Eddyville area (Dineen and Duskin, 1987).

The abrupt widening of the Wall Kill's floodplain between New Paltz and Tillson is controlled by the preglacial topography. The soft glacial deposits allowed the Wall Kill to migrate laterally. Thus, the floodplain of the Wall Kill is 4,000 ft wide in the stream reach between New Paltz and Tillson. It narrows to 500 ft to the south. The floodplain is 15 to 20 ft above the level of the stream channel, and is underlain by 11 to 22 ft of floodplain deposits in the New Paltz area. These deposits tend to become finer-grained towards the surface. The sinuosity of the river in this reach is 1.6. The Wall Kill's floodplain contains

Woodland through Late Archaic Indian artifacts, suggesting an age for the floodplain deposits of 700 to 5,000 yr (Len Isenberg, personal communication, Feb. 1987). The Wall Kill is deflected across a rock sill by the large glacial lake delta at Tillson (Dineen and Duskin, 1987) and flows through a rocky channel to its confluence with the Rondout Creek. The bedrock sill is the base-level control for this reach of the Wall Kill.

<u>STOP</u> <u>3:</u> Rondout Creek Floodplain at Napanoch (Fig. 4)
Ellenville, Napanoch, and Kerhonkson 7-1/2 minute quads

This section of the Rondout Creek's floodplain was mapped during a Cultural Resource Survey by Mr. Mark LoRusso of the NYS Museum (LoRusso, 1986). The floodplain north of the Eastern Correctional Facility is 2,000 to 3,000 ft wide and 6 to 20 ft thick. Several abandoned meanders are visible on its surface. It is developed downstream from a large alluvial fan that lies at the base of the Shawangunk Mountains. The floodplain deposits were intensely tested during the Cultural Resource Survey, but contained very sparse evidence of Indian occupations, although the meager sample of artifacts suggest an Archaic age (LoRusso, 1986).

The site is downstream from the large alluvial fan of the Rondout Creek at the Village of Napanoch. It was built where the Rondout enters its low-gradient middle valley. The upper Rondout drains the rugged foothills of the southern Catskill Mountains. The base-level of the central low gradient area is controlled by a bedrock sill at High Falls. The stream flows across deeply-incised glacial lake deposits (Dineen, 1986) that fill a preglacial valley (Figs. 2, 3c, and 9e). The preglacial valley is graded to the Albany Peneplain, and is cut into the Ashokan Peneplain. The valley also erodes a section of the Hoogeberg Peneplain (Fig. 2).

<u>STOP</u> <u>4:</u> Esopus Floodplain at Old Tongore Road Town Park (Fig. 4)
Mohonk Lake, Ashokan, Kingston West 7-1/2 minute quads

This stop is at the alluvial fan of the Esopus Creek that was built where the Esopus flows off of the Ashokan Peneplain and onto glacial lake deposits that clog a valley cut into the Albany Peneplain (Fig. 9b). The Esopus Creek's base-level for this reach is controlled by a bedrock spillway at Glenerie Falls. The stream meanders across a 3,000 ft wide floodplain that is 12 to 20 ft thick (Stop 1 in Dineen and Duskin, 1987). The sinuosity of the stream is 1.2 to 1.3 in this reach. Many oxbows are visible, especially near Kingston. Dr. Len Isenberg noted that many surface finds of Archaic artifacts occur on the surface of the Esopus Creek's floodplain (personal communication, Feb. 1987).

The buried valley contains a narrow inner gorge that is cut to sea level (Fig. 9a and b). The inner gorge extends south into

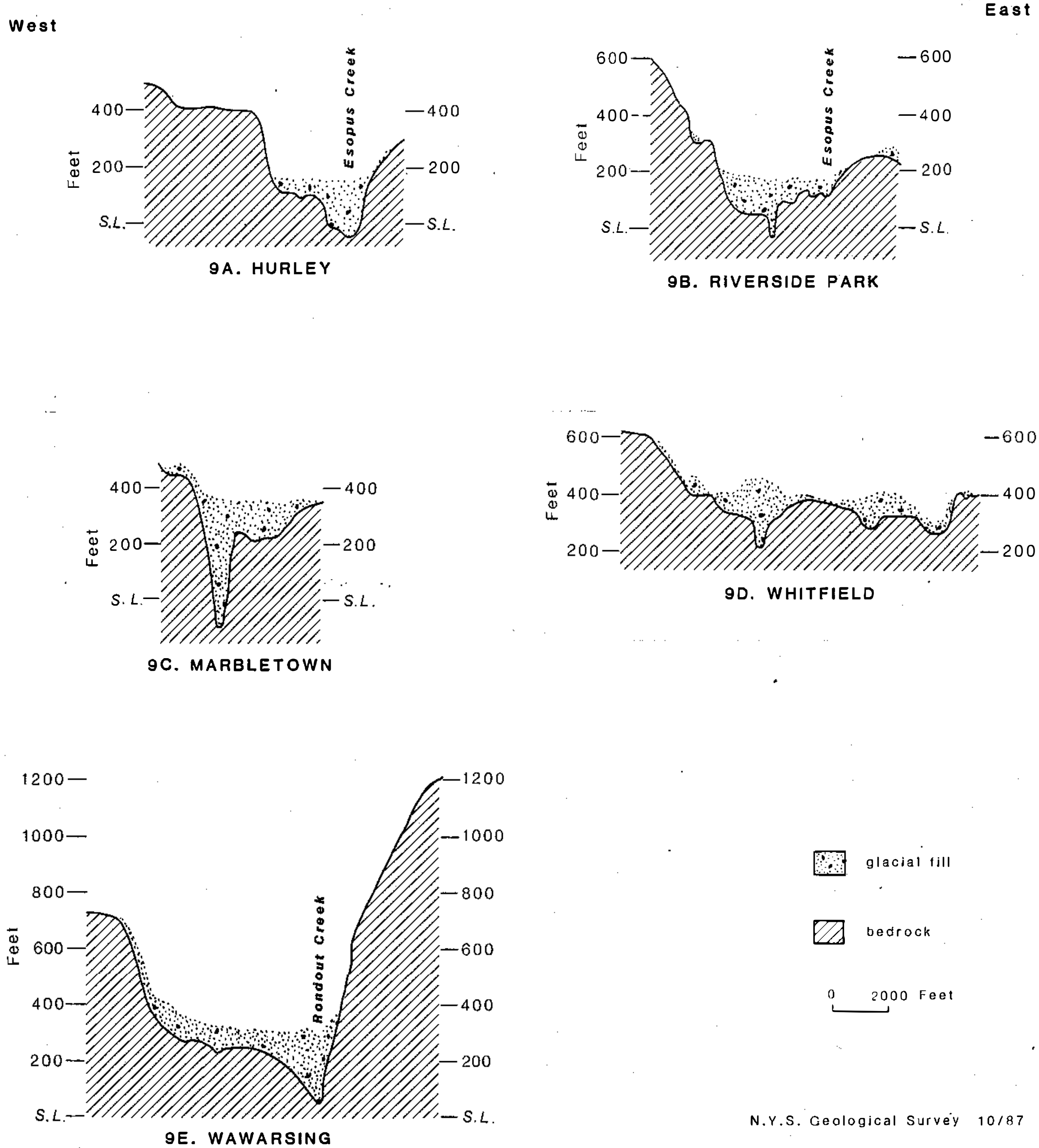

Figure 9.
Esopus-Rondout Cross Sections

the Marbletown area, although it narrows considerably (Figs. 9c and d). The Rondout-Esopus Valley contains a sequence of strath terraces that lie between the Hoogeberg and Albany Peneplains (Figs. 2 and 9d). The Albany Peneplain extends into the middle Rondout Valley through the High Falls water gap (Figs. 2 and 9d).

STOP 5: Kingston Point (Fig. 4)
Kingston East, Hyde Park, and Saugerties 7-1/2 minute quads.

The "inner gorge" of the Hudson is deeply incised into the Albany Peneplain in the Kingston area (Fig. 5d and 6). The inner gorge attains depths of 205 ft below sea level. The Castleton strath terrace lies at -80 to -100 ft in this area (Fig. 5d). The irregular surface of the Albany Peneplain is probably caused by glacial scour of the weak shale beds that lie between the relatively resistant sandstone and limestone layers. The Albany Peneplain clearly extends south as far as the Newburgh-Beacon Bridge (Fig 5f).

The Holocene deposits of this section of the Hudson's estuary are predominently silty sand to sandy silt with abundant organic matter (Figs. 5 and 6). The deposits overlie an unconformity that was carved into glacial deposits by the Hudson during the long period of lower sea level (12,000 to 4,000 yrs ago). The organic-rich silts and sands were deposited by the Hudson during the later stage of sea level rise. The Holocene unconformity lies at -20 to -30 ft at the Castleton Crossing of the Thruway, at -40 ft at the Rip Van Winkle Bridge, at -80 ft at the Kingston-Rhinecliff Bridge, at -120 ft at Poughkeepsie, and at -90 ft at the Newburgh-Beacon Bridge (Figs. 5 and 6). The excessive depth at Poughkeepsie is somewhat puzzling, it might be caused by either the presence of a glacial kettle hole, by catastrophic floods during deglaciation (Dineen and Duskin, 1987) or by tidal scour.

STOP 6: Catskill Point (Fig. 4)
Hudson South, Cementon, and Hudson North 7-1/2 minute quads

The bottom of the Hudson gorge is over 122 ft BSL at the Rip Van Winkle Bridge (Fig. 5c). It has been scoured into the Albany Peneplain. Remnants of the Hoogeberg Peneplain might exist at Mount Merino and the Becraft Mts., beyond the east end of the bridge.

The tidal flats and swamps south of the Village of Catskill are the Holocene delta of the Cats Kill. The tidal flats around Rogers Island are the southernmost extent of the Hudson's Holocene delta. Both of these deltas are composed of silty sand.

STOP 7: The Kaaters Kill at Timmerman Hill (Fig. 4)
Cementon, Hudson South, Saugerties, and Kaaterskill 7-1/2 minute quads.

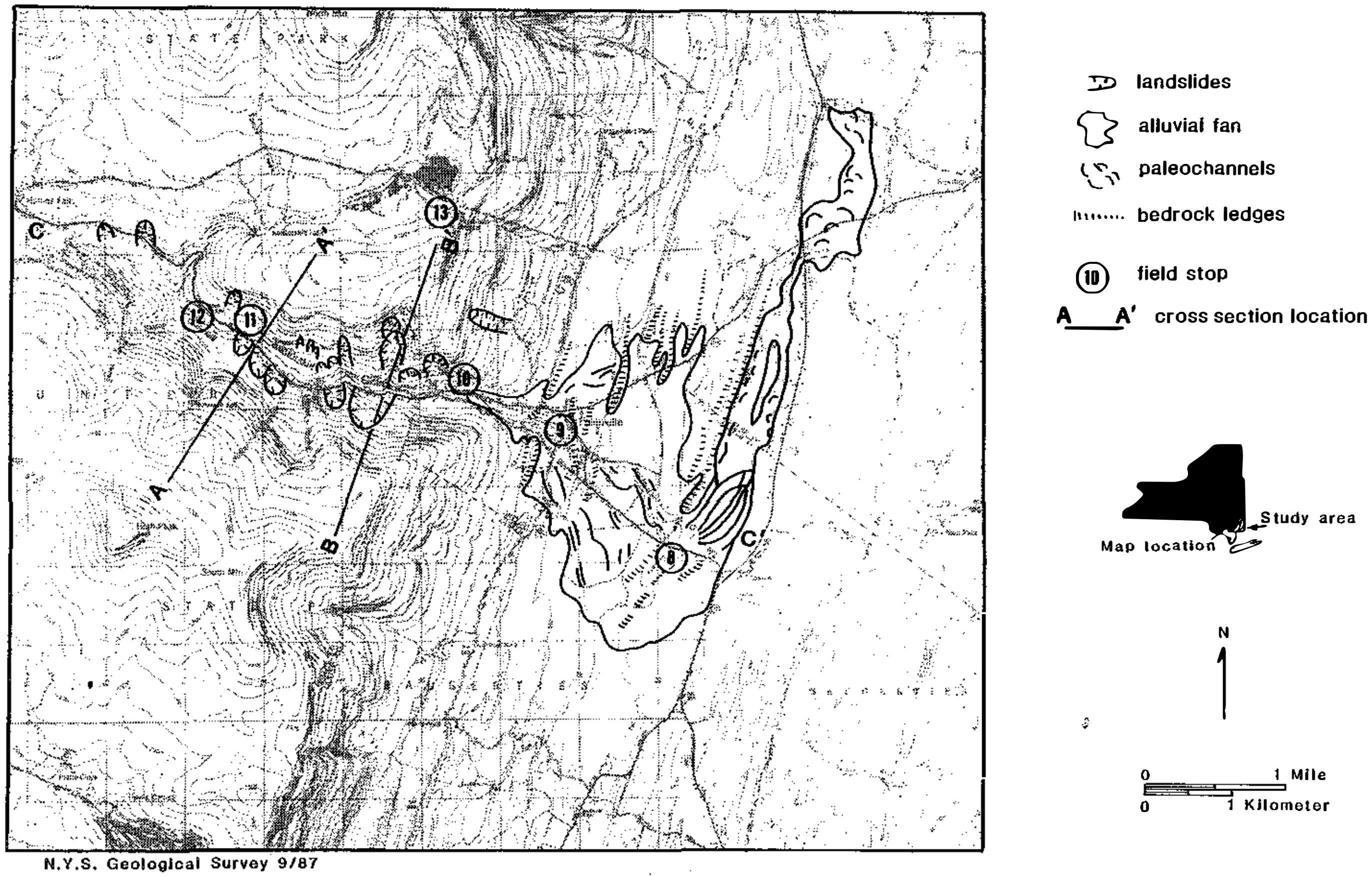

Figure 10. Kaaterskill Clove & Palenville Alluvial Fan

The Kaaters Kill's headwaters are in the eastern edge of the Catskill Mountains. The stream flows across the remnant of the Hoogeberg Peneplain and into the Bakoven valley at High Falls. The Hoogeberg is underlain by sandstones of the Mount Marion Formation. The Bakoven valley is underlain by the Bakoven Shales and is bordered on the east by the relatively resistant carbonates of the Onondaga Formation and the Helderberg Group that underlie the Kalkberg (Chadwick, 1944). The Bakoven valley was eroded to sea level by the late preglacial Cats Kill (Figs. 2, 4, and 11d). The Cats Kill entered the Bakoven valley through the dirt gap at Leeds Flats, flowed into the Esopus Valley at Mount Marion, and entered the Hudson's inner gorge through a dirt gap at Wilbur, near Kingston (Fig. 4).

The Kaaters Kill flows between deeply incised clay bluffs. These rounded bluffs resemble Dutch colonial baking ovens, hence the name "Bakoven" for the valley (Chadwick, 1944). The bluffs are failing by a myriad of landslides as the Kaaters Kill undercuts their base when it overflows its narrow floodplain every spring. The clays are over 80 ft thick in the Bakoven valley and overlie shale-pebble rich esker gravels. The base-level of this reach is controlled by the bedrock sill in the water gap at the Thruway's crossing of the Kaaters Kill.

STOP 8: Lower Palenville Fan (Fig. 10)
Kaaterskill, Woodstock, and Cementon 7-1/2 minute quads

The next four stops will give us an opportunity to examine several features of the Kaaters Kill as it leaves its upland headwaters and debouches onto the Hoogeberg Peneplain or piedmont. The stream begins near North Lake (STOP 13) on the dipslope of conglomerates that are part of the Onteora Formation (Fig. 11a). It spills over the edge of the Helderberg Peneplain at Kaaterskill Falls and enters the Kaaterskill Clove. It has a high gradient in the Clove (Fig. 11a). The Clove is carved into the sandstones and shales of the Kiskatom Formation. Many knickpoints have developed on the sandstone beds in the Clove (STOPS 10 and 11). The gradient flattens somewhat when the stream exits from the Kaaterskill Clove and flows across the surface of the Hoogeberg Peneplain. A large alluvial fan has been deposited at the mouth of the Clove (Fig. 10).

The Village of Palenville is built at the head of the fan (Fig. 10 and STOP 9). Abandoned braided stream channels (distributaries) traverse the fan's surface. The soil development is very poor on the surface of these sandy, cobbly gravels. The stream abandons its braided habit at the foot of the fan and meanders across the lake clays that mantle the Kiskatom Valley (Fig. 10). The stream's gradient across the alluvial fan is 0.034 or 180 ft/mile.

STOP 8 is near the distal edge of the fan (Figs. 10 and 11). The stream cut next to the the road exposes clean, open-work,

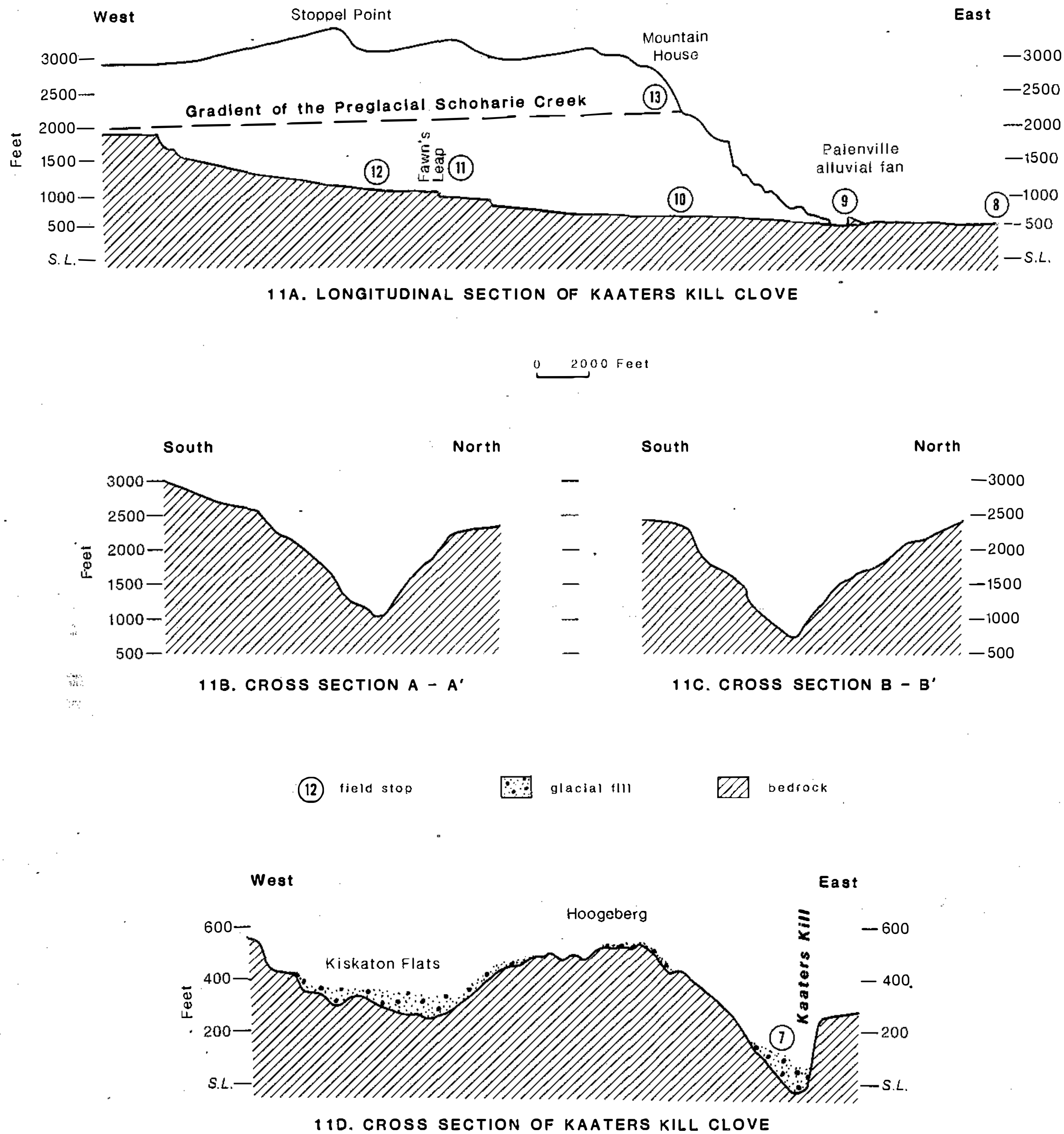

Figure 11.
Kaaters Kill Clove Longitudinal Section and Cross Sections

imbricated cobbles that are interbedded with muddy matrix-supported cobbly gravels. During low stream flow stages, the stream disappears into the open-work cobbles exposed in the streambed. Rock is exposed in the streambed and the stream flows across a rock ledge upstream at the bridge. Large swampy areas lie along the foot of the fan, thus many of the camps in that region are built on stilts.

The muddy gravels were probably deposited as either wet sediment flows during catastrophic floods or as sieve deposits left as the stream waters flowed into the highly permeable channel deposits, and the open-work cobble beds are probably channel deposits of more "normal" flows. The outcrops of ledge rock are "mini-hogbacks" of Mount Marion sandstones that have been incompletely covered by the fan. The stream channel is approximately at the the same height as the adjacent road, so the stream could break through the intervening levee and to spill onto the roadway, thus creating a new distributary!

STOP 9: Red House at Head of Fan, Village of Palenville (Fig. 10)

The head of the Palenville alluvial fan can be examined at this stop. The Kaaters Kill crosses a bedrock ledge as it exits from the Kaaterskill Clove. The stream gradient is abruptly reduced, causing the stream to deposit the coarse bedload that it carried in the Clove. Many 1-meter diameter clasts are deposited each Spring in the backyards of the people that live next to the creek. A significant number of these boulders are composed of limestone, a lithology that is not native to the Clove. The primary upstream source of limestone appears to be the rip-rap that is emplaced along the roadbed of Route 23A. These limestone clasts might have traveled a mile from their origin in the roadbed! The fan head is deeply trenched by the stream channel. It is composed of coarse-grained material.

STOP 10: Intermann's Bridge (Fig. 10)

The stream flows in a steep-walled valley upstream from STOP 9. The floodplain is thin in this section, exposures are less than 6 ft thick. The floodplain deposits are also very ephemeral in the Clove- they have been deeply scoured several times since 1890. The bridge and local houses have been swept away in those floods (Bonafede, 1980). The bridge's 1850 foundations are on rock and usually survive the floods, so they are reused in succeeding bridges. Landslides and rockfalls are common in the Clove (Fig. 10; Bonafede, 1980).

The records of the NYS Dept. of Transportation identify many landslides and seeps along the road from Intermann's Bridge to Moore's Bridge (the bridge near Fawn's Leap). The roadbed crosses a buried valley with over 100 ft of "hard to compact red clayey silt with angular gravel" (till) approximately mid-way between the two bridges. The records also note that the road was severely washed-out during a hurricane in 1935.