STRATIGRAPHY AND STRUCTURE OF THE "CATSKILL GROUP" IN SOUTHEASTERN NEW YORK

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TRIP D

> "A blackboard drawing or a textbook illustration of a sedimentary facies has quite a different appearance from a sedimentary facies when one encounters it in the field. In the field, facies changes seem baffling and bewildering, especially in an area of new and unknown stratigraphy. It is as if stratigraphy, hitherto subject to natural laws and capable of rational analysis, had suddenly gone lawless and planless."
>
> P. B. King

THE CATSKILL PROBLEM

Introductory Statement

Within the Devonian rocks of southeastern New York there are approximately 5000 feet of interbedded red and gray sandstones, shales and conglomerates known collectively as "Catskill." After more than a century of investigation, virtually the only conclusions agreed upon by the various workers in the area are that the facies changes are complex, the location of formation boundaries is difficult, few fossils are present, correlation is uncertain, and the sedimentary environment is either subaerial or subaqueous.

The complex intertonguing and intergrading of strata of the Catskill delta offers excellent opportunity for the study of sedimentary facies. The rocks which comprise the "Catskill group" exhibit exceptional intricacy because of three major variations: lateral and vertical intergradation of lithologies, lateral intertonguing of lithologies, and changes in color. The first facies variation is represented by changes in grain size in the sandstones and conglomerates. Grain size increases vertically in the stratigraphic section and decreases laterally from east to west. Intertonguing of lithologies is expressed by the relationship between the red siltstone and the shale beds and the green- and blue-gray sandstones. The red beds thin or "pinch out" toward the western portion of the Catskill delta. Whereas the previous two facies changes are gradual, color changes often occur within a few feet. The red color is caused by the presence of finely divided hematite; the blue- and green-gray colors by chlorite, magnetite and other dark minerals.

Conditions of Deposition

The two views of the environment of deposition of the sediments are well expressed by J. J. Stevenson (1891) and Joseph Barrell (1913). Barrell, whose interpretation has been the generally (if not dogmatically) accepted one, believed the sediments represent subaerial deltaic deposits derived from a high, nearby source. He pictured the paleogeography as a low alluvial plain shading off through fringing lagoons into a shallow mud-bottomed sea. Stevenson, on the other hand, concluded that the strata were laid down in a shallow basin undergoing differential subsidence in which the basin was connected with the open sea. To him, the lack of animal life was not, as Barrell believed, caused by the fact that marine life cannot exist in a subaerial deltaic environment. Stevenson claimed that the environment was unfavorable because of the influx of large quantities of river silt into the basin.

A number of criteria have been given in support of the theory of subaerial deposition. The two most quoted are the large amounts of red sediments and the lack of marine fauna. Red color in sediments has always signified an oxidizing environment. The lack of marine fossils, although negative evidence, points to a nonmarine origin. Other, and perhaps less conclusive, criteria are alleged raindrop prints, rootlet markings and mudcracks. Conglomerates, cut-and-fill structures, cross-stratification, plant fragments and the presence of the large pelecypod Amnigenia catskillensis, believed to be a fresh water clam, have also been put forth by various investigators as evidence for continental sedimentation of the "Catskill" rocks. A proponent of the subaqueous theory of deposition must either disprove the presence of the features which have been accepted as conclusive proof of subaerial environment or give reason for their presence. The field trip has been designed so that most of the features may be observed and their validity evaluated.

Source Area

The direction of lateral grain size diminution, currect direction criteria, i.e. cross-bedding, primary current lineation and oriented plant fragments, and "lensing-out" of the red beds seem to indicate a source area to the east of the present outcrops. In 1914, Barrell stated that the sediment was brought in along the whole front of the geosyncline by more than one river. He did not draw an analogy with the present day Mississippi River delta, but instead, pictured a series of deltas in which there were several centers of growth. Preliminary study of directional properties indicates two major directions of sediment transport. The two directions, N 20° W and N 90° W, alternate several times vertically in the stratigraphic section. Mencher (1939) believed in a fairly close source of sediment derivation. He thought it inconceivable that material in which the grains are extremely angular could have been transported from more than 75 miles from the present eastern limit of the outcrop. Thus far, no one has been able to propose a source area which adequately explains the presence of the conglomerates in western New York as well as those in the region of the Catskill front.

STRATIGRAPHY

What is Catskill?

The first appearance of the name Catskill as a geologic unit is found in the Fourth Annual Report of the First Geological District by W. W. Mather (1840). Mather defined the Catskill Mountain Group as consisting of white, gray and red conglomerates with gray, red, olive and black grits, slates and shale. He chose the Catskill front in the vicinity of Kaaterskill Clove as the type section and included in the group all of the strata from the Onondaga Limestone to the Pottsville Conglomerate. The latter Mather thought capped the Catskill Mountains.

The term "Catskill group," as used here, has no formal stratigraphic connotation, but is employed in an informal sense to designate the massive wedge of interbedded, Devonian red and gray strata which crop out in southeastern New York. Therefore, the name denotes geographic as well as stratigraphic location. This course is taken only because the name appears to be irretrievably entrenched in geologic literature and to discard it entirely (perhaps the best course of action) would only serve to complicate an already confused situation (see Chadwick, 1936).

Hawks Nest Formation

The name "Delaware River Flags" was first applied by I. C. White in 1882 to the rocks which overlie the marine Hamilton (?) beds just north of Port Jervis, New York. He reported a thickness of approximately 1400 feet. Willard (1936) redefined the formation as 1500 feet of greenish flags without red beds. He states that the formation is correlative with the Onteora Formation of the Catskill front. However, he fails to give an adequate reason for the disappearance of almost 3000 feet of red strata (the combined thickness of the Onteora and pre-Onteora red beds) which is necessary to support such a correlation. Examination of rock samples from exploratory oil and gas wells in the area has shown that a thick sequence of red strata occurs in the upper 700 feet of Willard's Delaware River Flags. This sequence of red beds can be traced, in a series of wells, north along the Delaware River and into the region of Oneonta, New York, where it is called the Oneonta Formation. This has prompted Fletcher to discard the name Delaware River Flags. The section of gray sandstones and shales which, in southeastern New York, lie beneath the Oneonta Formation, are defined as the Hawks Nest Formation after the excellent exposures on the high cliffs at Hawks Nest, N. Y. This 800 foot sequence of strata is probably correlative with the Unadilla Sandstone of the Oneonta region.

The dominant lithology is a fine- to medium-grained, light to medium bluish gray subgraywacke. The fine-grained sandstones are finely laminated and flow rolls are common. The medium-grained sandstones exhibit low angle cross-bedding. A limonite stain is present on the weathered rock surface. Interbedded with the sandstones are medium dark gray to grayish blue siltstones which are brownish gray on weathered surface and lack fissility. The formation is generally unfossiliferous.

Oneonta Formation

In the same report in which Mather defined the Catskill Mountain Group, L. Vanuxem (1840) proposed the name "Montrose sandstone or sandstone of Oneonta" for the red and gray rocks found in Otega, Broome and Chenango counties, New York. The Geologic Map of New York shows these 700 feet of strata correlated with the Onteora Formation. Fletcher, however, has suggested an alternative correlation (see Plate IV). Stratigraphic columns constructed from samples from gas wells located in the northeastern Catskill Mountains show that only the lower 800 feet of Chadwick's Kiskatom red beds "drop out" before they reach the type section of the Oneonta Formation. Beneath the Twilight Park Conglomerate is a 900-foot zone of predominantly red strata, 250 feet of dark gray shale and sandstone with two thin beds of coarse-grained, white quartzose sandstone, and about 800 feet of intercalated red and dark bluish gray sandstone and shale. The 250 feet of rock containing the two thin white sandstone beds forms a distinctive and persistent marker horizon in subsurface samples. This zone has been traced to the Durham quadrangle where it was called by G. A. Cooper (1934) the eastern equivalent of the Portland Point Member of the Moscow Formation. In the Durham quadrangle the zone is underlain by 350 feet of red beds. In the Margaretville quadrangle, west of the Catskill front, only 100 feet of red beds underlie the white sandstone units. At the type locality of the Oneonta Formation this zone is located approximately 900 feet beneath the lowest red bed. As a result of these findings the strata Chadwick called Kiskatom have been divided into three units. The lower red zone, which loses its red beds rapidly to the west and south, is designated the Plattekill Formation and its type section is taken as Plattekill Clove. The middle zone is called the Potter Hollow Formation after Potter Hollow, Greene County, New York. The upper red zone is the Oneonta Formation.

The Oneonta contains micaceous, pale red purple and grayish purple siltstones and mudstones. The red mudstones exhibit slickensides formed by slumping of unconsolidated mud before induration. The sandstones are medium grained, red purple and light gray to greenish gray subgraywackes. They weather light greenish gray. The flaggy sandstones have primary current lineations on bedding surfaces and, with the exception of one type of freshwater (?) pelecypod and plant fragments, are unfossiliferous.

Kattel Formation

The name Kattel was first used by Chadwick (1932) for the marine shale previously designated as lower Enfield. The lithology is similar to the Chemung facies and consists of fossiliferous gray and dark gray shale interbedded with thin gray and brownish gray siltstones. Although it is easily recognizable in subsurface samples because of its stratigraphic position between the red Oneonta and Onteora Formations, the fossiliferous portion does not extend to the southeast past Hancock, New York. Therefore, separation of it from similar units in the underlying and overlying formations around Barryville, where the Kattel should crop out, has not be accomplished. If Fletcher's tracing of the Oneonta Formation to the Catskill front is correct, then the Kattel Formation is correlative with the Twilight Park Conglomerate and, perhaps, with the Kaaterskill Sandstone.

Onteora Formation

The Onteora Formation was defined by Chadwick (1933) as the 1150 feet of red and gray beds which lie between the Twilight Park Conglomerate and the Stony Clove Sandstone in the vicinity of High Peak and Round Top Mountains, Greene County, New York. The name is derived from the Indian name for the Catskill Mountains which means "hills of the sky." The lithology differs very little from the underlying red and gray strata. Subtle increase in grain size in the sandstones occurs, but is almost imperceptible to cursory examination.

By considering the Kiskatom Formation as belonging to the Hamilton Group, it becomes necessary to correlate the Onteora red beds (which then must be Upper Devonian in age) with the Upper Devonian red beds to the west - the Oneonta. If, however, the Oneonta Formation actually lies beneath the Twilight Park Conglomerate as Fletcher proposes, the Onteora is equivalent to the sequence of strata called the West Danby Shale and Sandstone (upper Enfield) and, farther to the west, the Cashaqua Shale.

Stony Clove Formation

Chadwick (1944) described the Stony Clove Formation as "gray sandstones coarsely flaggy and without a noticeable trace of red color through a thickness of eight or nine hundred feet." The formation's type locality is the "deep and constricted pass of Stony Clove," Greene County, N. Y. This formation has a marked physiographic effect on the Catskill front. It forms a distinct escarpment which can be traced topographically along the front. Along the Delaware River the Stony Clove forms high cliffs in contrast to the lower topography caused by the less resistant red musstones and shales of the surrounding Onteora and Damascus Formations. Chadwick's correlation of the Stony Clove with the Kattel Formation was based on "... color, lithology, proper expected thickness and general position ..." The same criteria could be invoked to support correlation with the lower part of the Rhinestreet Shale.

Damascus Formation

Above the Stony Clove Formation in the Delaware River region are about 400 feet of strata composed almost entirely of red sandstone, siltstone, mudstone and shale. Willard (1936) gave the name Damascus Formation to these rocks after Damascus, Pennsylvania where this sequence is well exposed. These strata were originally named "Montrose" by White (1882) who believed they were the same red beds which crop out around Montrose, Pennsylvania. Fletcher has correlated the Damascus with the basal portion of the Katsberg Formation, called Lower Katsberg on the Geologic Map of New York State. At the type locality the formation lies in the center of a large syncline (see section on structure), so that along the Delaware River older beds occur both to the south and north of the outcrop of the Damascus Formation.

The sandstones are fine- to medium-grained and are grayish red purple. The few interstratified greenish gray sandstones range from medium- to coarse-grained. Both red and gray sandstones exhibit cross-stratification. The red mudstones and siltstones strongly resemble the same in the two previously described red formations; however, more of the fissile red shale is found in the Damascus Formation.

Post-Damascus Formations

The strata above the Damascus Formation in Pennsylvania have been divided into the Honesdale, Cherry Ridge, Elk Mountain and Mount Pleasant Formations. These units have not been recognized in New York. Along the Catskill front Chadwick (1933) proposed the name Katsberg (the old Dutch name for the Catskill Mountains) for the almost 1500 feet of rocks between the Stony Clove Sandstone and the Slide Mountain Conglomerate. The lower part of the Katsberg Formation, mainly red sandstones and shales, is correlated with the Damascus. The upper portion, as yet not adequately differentiated, consists of coarse-grained greenish-gray and red sandstones and white quartz pebble conglomerates with red and green sand matrix. Chadwick (1936) believed that "it is embarrassing to have any formation name lap across a subperiod line, such as that between the Middle and Upper Devonian." His stratigraphic interpretations are founded on this thought. The result (see Plate II and figure 1) is that he applied different names to rock zones which are stratigraphically continuous because they transgressed time boundaries. To strata which are actually stratigraphically equivalent to the Katsberg Formation, he gave the names Catawissa and Montrose.

Capping the highest peak in the Catskills, Slide Mountain, is a very distinctive quartz pebble conglomerate which bears the name of that peak. The formation is 400 feet thick and was named by Chadwick in 1933. The conglomerate, which contains white quartz pebbles commonly greater than 70 mm. diameter, is cross-bedded and weathers whitish or greenish yellow. Besides the quartz pebbles, a few green siltstone pebbles may also be found. The lithology is strikingly similar to the conglomeratic portions of the Pocono Sandstone. If the two are correlative, Slide Mountain may be an outlier of the more westerly plateau area of Pennsylvania.

STRUCTURE

General Statement

The dominant structural feature of the region is a synclinorium in which the axis plunges southwest and passes through Hunter, New York and Damascus, Pennsylvania. The strata of the southeastern flank strike about N 30° E and dip to the northwest at angles which vary from 40° at Ellenville, N.Y. to less than 1° in the vicinity of Liberty, N.Y. The strata of the western flank strike N 85° E and dip toward the south at angles of 2° just north of the Gilboa Reservoir to less than 1° along the Pepacton Reservoir. Many small local flexures are superimposed on the regional structure. Combined with the facies changes and lack of marker beds, these subtle changes in dip angles and directions make stratigraphic interpretation difficult.

Fractures and Fracture Systems

Two major joint sets are present. The first set strikes almost due north and is generally vertical. The joint face is smooth and its trace is straight. Plumose markings are common and, along the Delaware River outcrops at least, mineralization has occurred along the joint planes. The second set strikes N 85° E and is also vertical. However, the joint faces are rough and their traces are wavy. Plumose markings are also present on the joint planes of this set, but no mineralization has taken place. Both sets of joints are well expressed in the sandstones, but do not occur with any regularity in the shales and siltstones. In these finer grained rocks there is small scale "crinkling" caused by minute slippage along microjoints which parallel the east-west joint set.

In the sandstones, parting of the strata also occurs along the bedding planes between the topset beds and between the foreset beds. This parting, caused by the parallel alignment of small plates of muscovite along the stratification planes, makes possible the flagstone industry of the Catskill Mountains. The presence of slickensides along a few of the bedding planes of the sandstones indicates that some movement has taken place. The slickensiding is probably the result of gentle flexure folding.

Some faults with small displacements have been noted. One good example may be seen along the southern shore of the Pepacton Reservoir just east of Downsville, N. Y.

THE PROBLEM AGAIN

The Pocono-Catskill Contact

Two alternatives have been suggested for the contact between the "Catskill group" and the Pocono Formation (see Plate VI). In eastern Pennsylvania the lower boundary of the Mississippian Period has been placed at the base of the Pocono Sandstone. However, the confusion in identification between the Pocono and the Honesdale-type sandstone and conglomerate by early workers in Pennsylvania is well known. Willard (1936) concludes that the contact between the Mount Pleasant Red Shale (the highest formation of the "Catskill group" in eastern Pennsylvania) and the Pocono Formation is unconformable. He states, "The writer has long entertained the feeling that this lithologic change in passing from the Devonian to the Mississippian continental formations is the direct expression of a marked orogenic movement...." This conclusion is based on the fact that the Mount Pleasant Formation thins rapidly to the west and the nature of the contact, which is locally irregular. He says that the thinning is due to subaerial beveling, even though "...nowhere has an angular discordance of dips been seen." Thus, Willard says that the Pocono was subsequently deposited upon this erosion surface. A very different picture can be constructed if the "thinning" of the Mount Pleasant Red Shale is caused by facies change. Also, irregular contacts between sandstone and shale units are the rule and not the exception in the "Catskill group." If, as suggested earlier, the Pocono and Slide Mountain Formations are equivalent, where, then, should the Devonian-Mississippian contact be located?

Concluding Remarks

The interpretation of stratigraphic relationships in the Catskill delta presented here differs from those commonly accepted only with respect to the magnitude of the facies changes. The fact that red beds were being deposited in the eastern part of New York State at the same time black shales were being laid down in the western portion has been well documented. Plate VII shows the three types of facies changes mentioned previously. At any particular stratigraphic level grain size decreases from east to west. This is true because each level transects the more landward portion of the sedimentary basin in the east and passes to deeper water environmental conditions toward the west. If carried far enough the sequence at a particular level from east to west is: red shale, sandstone and conglomerate - gray fossiliferous shale and sandstone - black shale and limestone.

The vertical grain size increase is the result of the gradual regression of the sea from the eastern part of the basin. The diagram also shows that the marine units attain their greatest thickness in the west; while the red beds are thickest in the east. This results in intertonguing of the two lithologies. All units do not thicken toward the east at a constant rate as once thought.

The location of time boundaries in the eastern portion of the Catskill delta can be perilous, indeed. However, it appears that the Twilight Park does not mark the base of the Upper Devonian. Actually, Upper Devonian sedimentation began somewhere in the lower portion of the Oneonta red beds. The imaginary line denoting the base of the Upper Devonian crosses the facies from the red beds through the Unadilla-type rocks and into the black shales of the Geneseo Formation. Only at local outcrops can one say that a particular unit lies at the top of the Middle Devonian or at the base of the Upper Devonian.

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ROAD LOG

Mileage	Description
0.0	Junction of Rtes. 209 and 6. Proceed north to Rte. 97.
0.8	Point Peter, Port Jervis, N. Y. Outcrop of dark gray shales and sandstones called Portage by Willard (1936) and marine Devonian beds on the Geologic Map of Pennsylvania. These rocks contain many of the same fauna as the Mount Marion Formation along the Catskill Front.
3.2	Junction of Rtes. 97 and 42. Continue straight ahead (north) on Rte. 97.
3.9	Beginning of outcrop which shows the type section of the Hawks Nest Formation.
5.1	STOP #1. Type section of Hawks Nest Formation.
5.6	Cross the Mongaup River.
8.1	Outcrop at left along the river. A clear expression of the regional dip, cross-bedding, and joint pattern.

10.2 Large quarry at the right.

11.2 Bridge at Pond Eddy, N. Y.

12.0 Sandstone outcrop on Pa. side of the river.

13.3 Outcrop at right.

13.9 STOP #2. Outcrop of the Oneonta Formation.

14.9 Sandstone outcrop along railroad on Pa. side of river.

16.1 Sandstone outcrop on right side of highway. Notice well-expressed joint sets. Red siltstone at top of hill.

17.1 Outcrop along railroad on Pa. side.

18.2 Outcrop of sandstone on right side of highway. Cross-stratification is absent. Red siltstone near bottom of hill.

18.8 Junction of Rte. 55 and 97. Continue straight ahead (north) on Rte. 97 through Barryville, N. Y.

20.2 Outcrop on right. Watch for appearance of red mudstone which indicates the regional dip.

23.0 Minisink Ford. Continue on Rte. 97. Lackawaxen River enters the Delaware River at this point.

23.3 Large outcrop of the sandstone on the right.

26.6 Outcrop showing well-developed cross-stratification.

28.2 Outcrop on both sides of the highway. Red siltstone and a dark gray shale are exposed.

28.5 Outcrop of the Barryville member of the Shohola Formation (see Willard, 1936). Notice the distinctive weathering "holes."

30.0 Cross the Ten Mile River.

30.5 Sandstone outcrop at left showing well-developed cross-stratification.

32.9 Junction of Rtes. 52 and 97. Continue north on Rte. 97.

33.7 Rte. 52 leaves Rte. 97. Bear right and continue on Rte. 97.

34.7 Outcrop near the top of the sandstone on the right side of the highway.

39.9 Outcrop at right. Notice the abundance of red soil.

40.2 Red siltstone exposure at right.

41.2 Red siltstone exposure at right.

41.4 Outcrop of red siltstone and mudstone on right side of highway. Notice anticlinal structure.

42.0 STOP #3. Type locality of the Damascus Formation.

42.5 Red shale and mudstone exposed on both sides of highway.

42.7 Lea e Rte. 97 and bear to the right (east).

47.6 Fosterdale, N. Y. Junction of Rtes. 52 and 17B. Turn left (north) on Rtes. 52 and 17B.

48.1 Leave Rte. 17B. Bear right on Rte. 52.

49.1 Outcrop of gray sandstone in Damascus Formation at right.

50.3 Continue on Rte. 52 through Kenoza Lake, N. Y.

51.4 Junction of Rtes. 52 and 52A. Turn right (east) and continue on Rte. 52.

53.9 Continue on Rte. 52 through Jeffersonville, N. Y.

64.6 Red sandstone exposure at right.

66.3 Liberty, N.Y. Junction of Rtes. 52 and old Rte. 17. Turn right (south) and continue on Rte. 52.

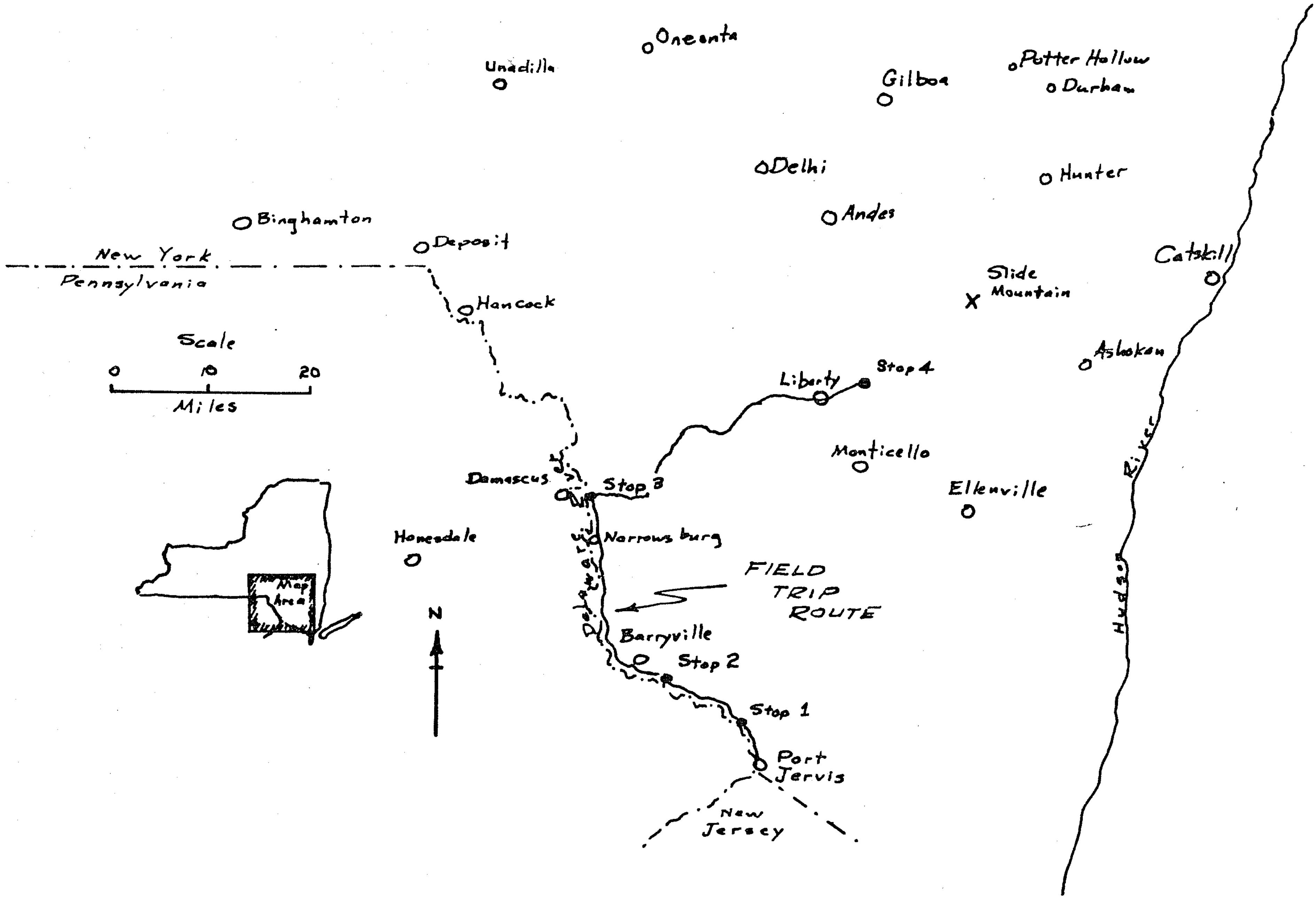
66.7 Junction of Rtes. 52 and 55. Turn left (east) and proceed on Rte. 55.

72.0 STOP #4. Outcrop of the Lower Katsberg Formation.

END OF ROAD LOG

Return to Port Jervis via Rtes. 55, 17 and 209.

SKETCH MAP OF SOUTHEASTERN NEW YORK



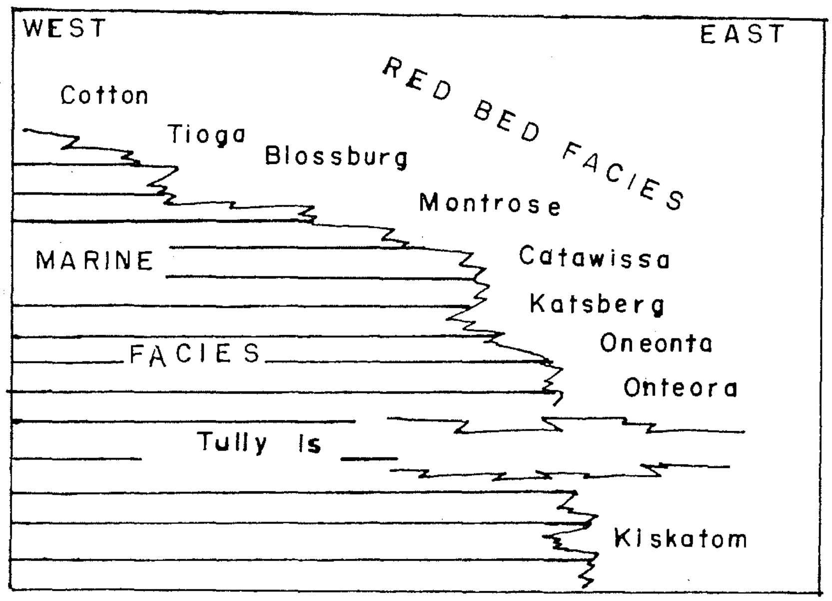
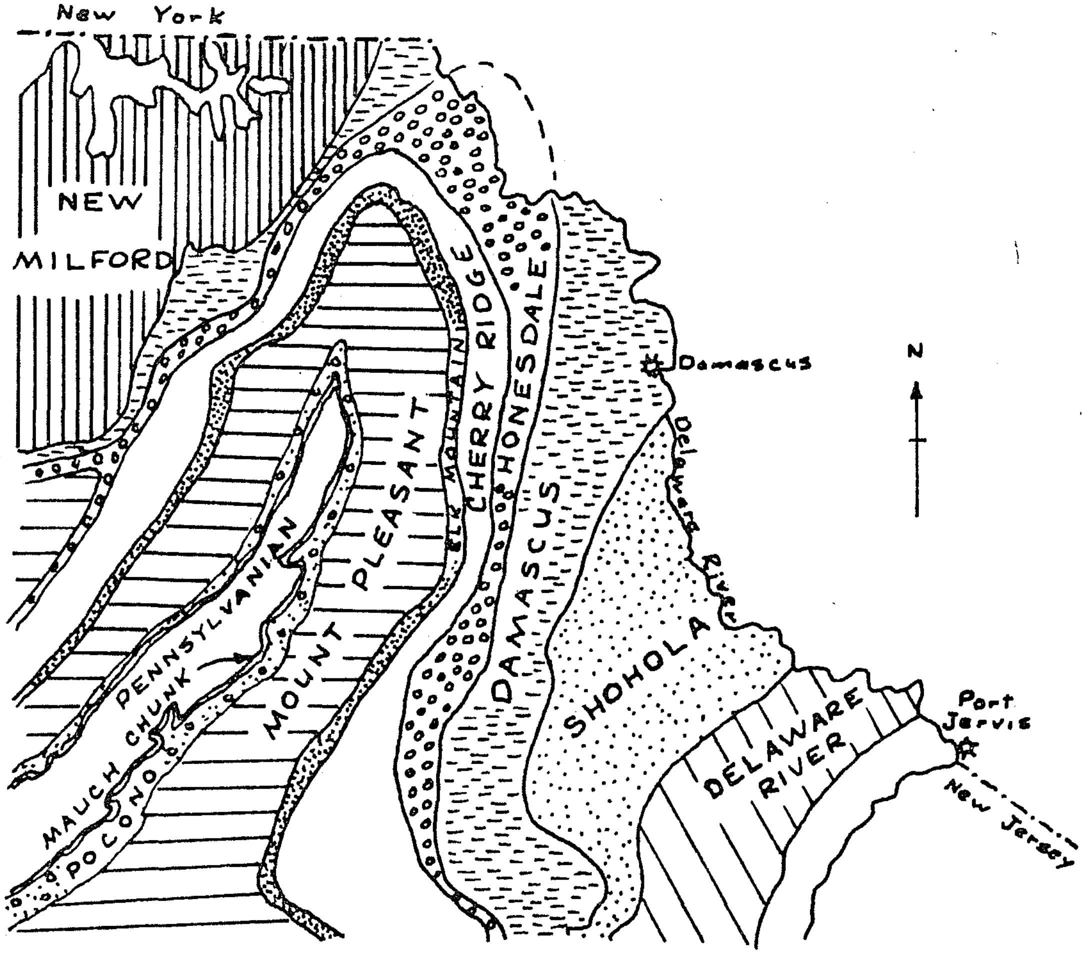


Figure I. (Suggested by Fisher, 1956, Jour. Geology, v. 64, p. 621, fig. 2.)

WILLARD'S INTERPRETATION OF CATSKILL STRATIGRAPHY



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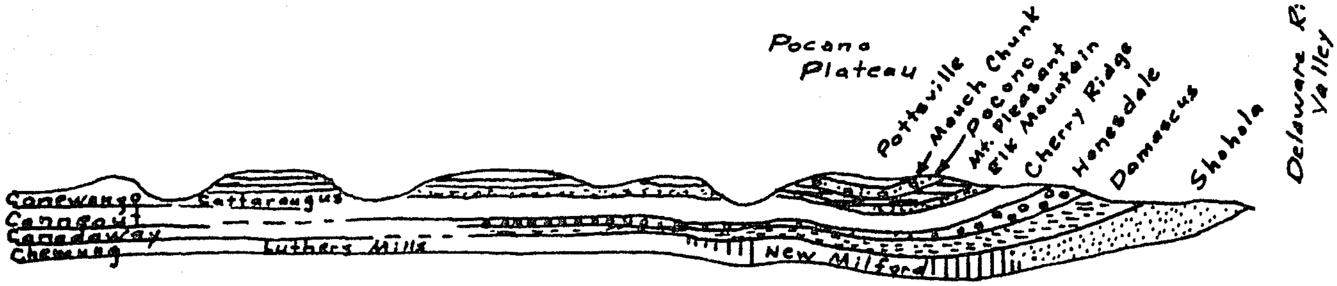
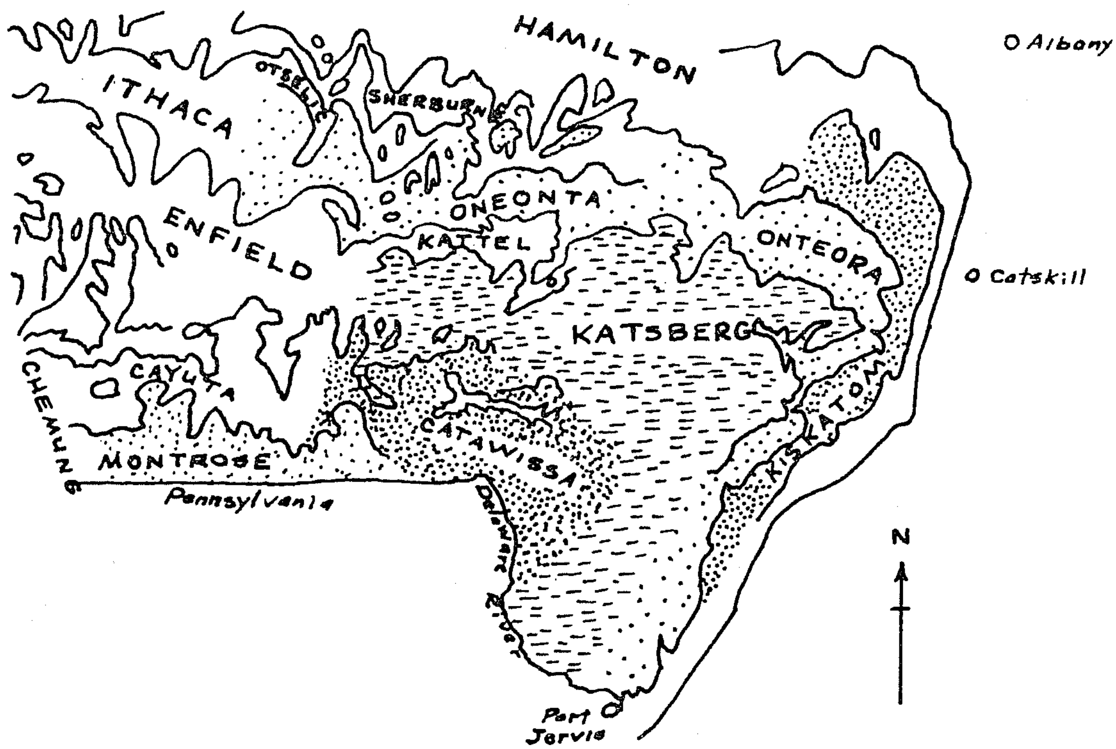


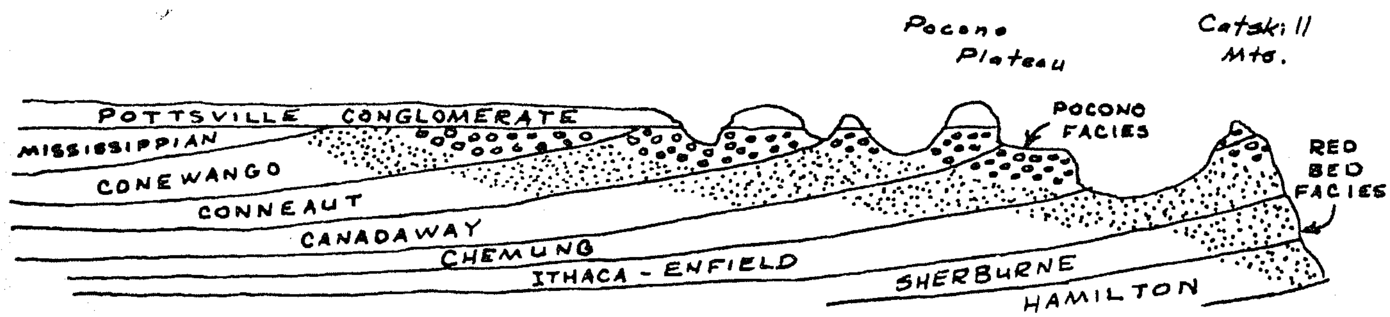
(After Willard, 1936, Geol. Soc. America Bull., v. 47, p. 602, fig. 3-B.)

PLATE I

CHADWICK'S INTERPRETATION OF CATSKILL STRATIGRAPHY



(After Chadwick, 1944, N. Y. State Mus. Bull. 307, p. 9, fig. 3.)



(After Chadwick, 1935, Am. Jour. Sci., 5th ser., v. 29, p. 134, fig. 1.)

PLATE II

CORRELATION CHART

Suggested by the Geologic Map of New York State - 1962 Edition

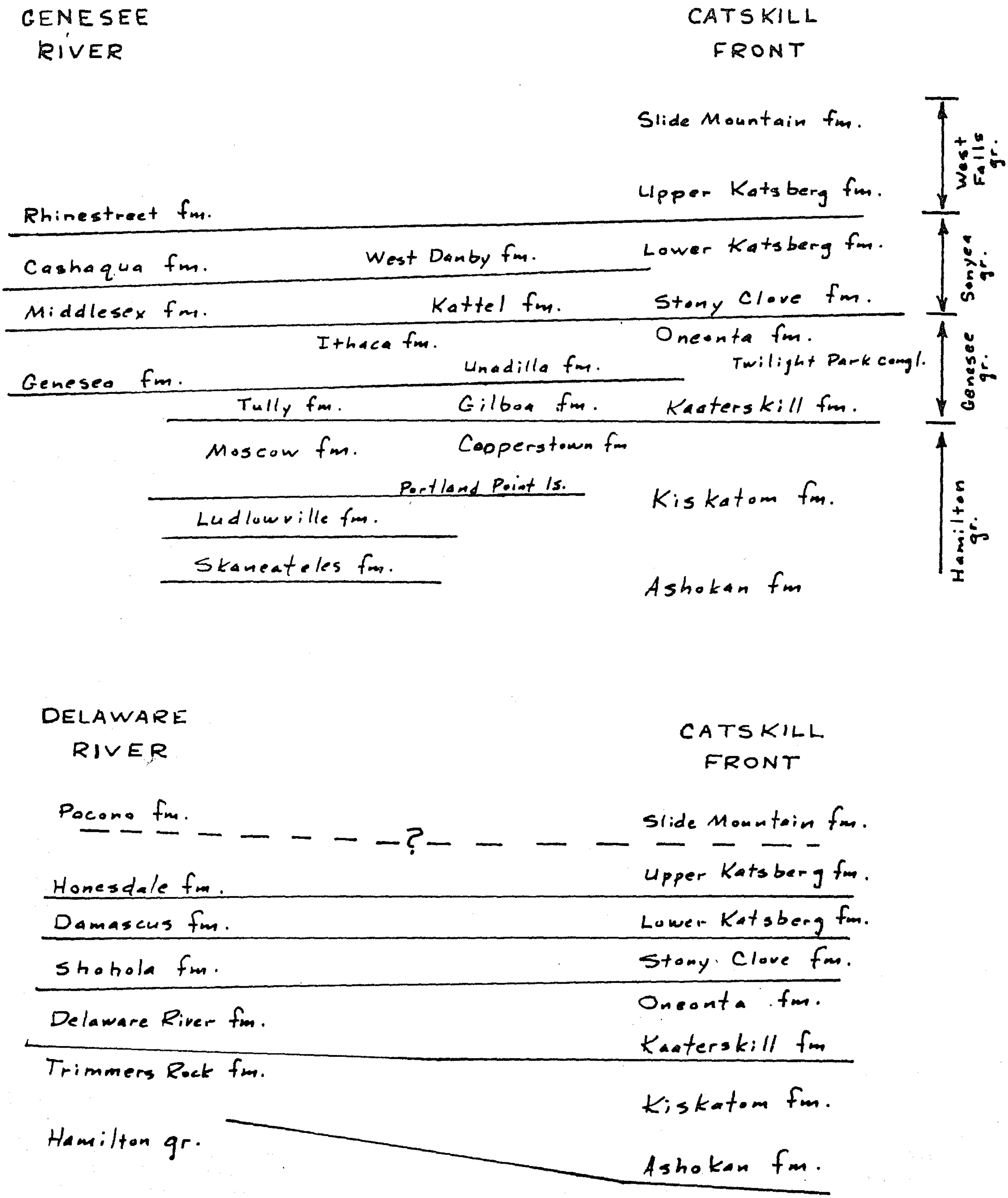
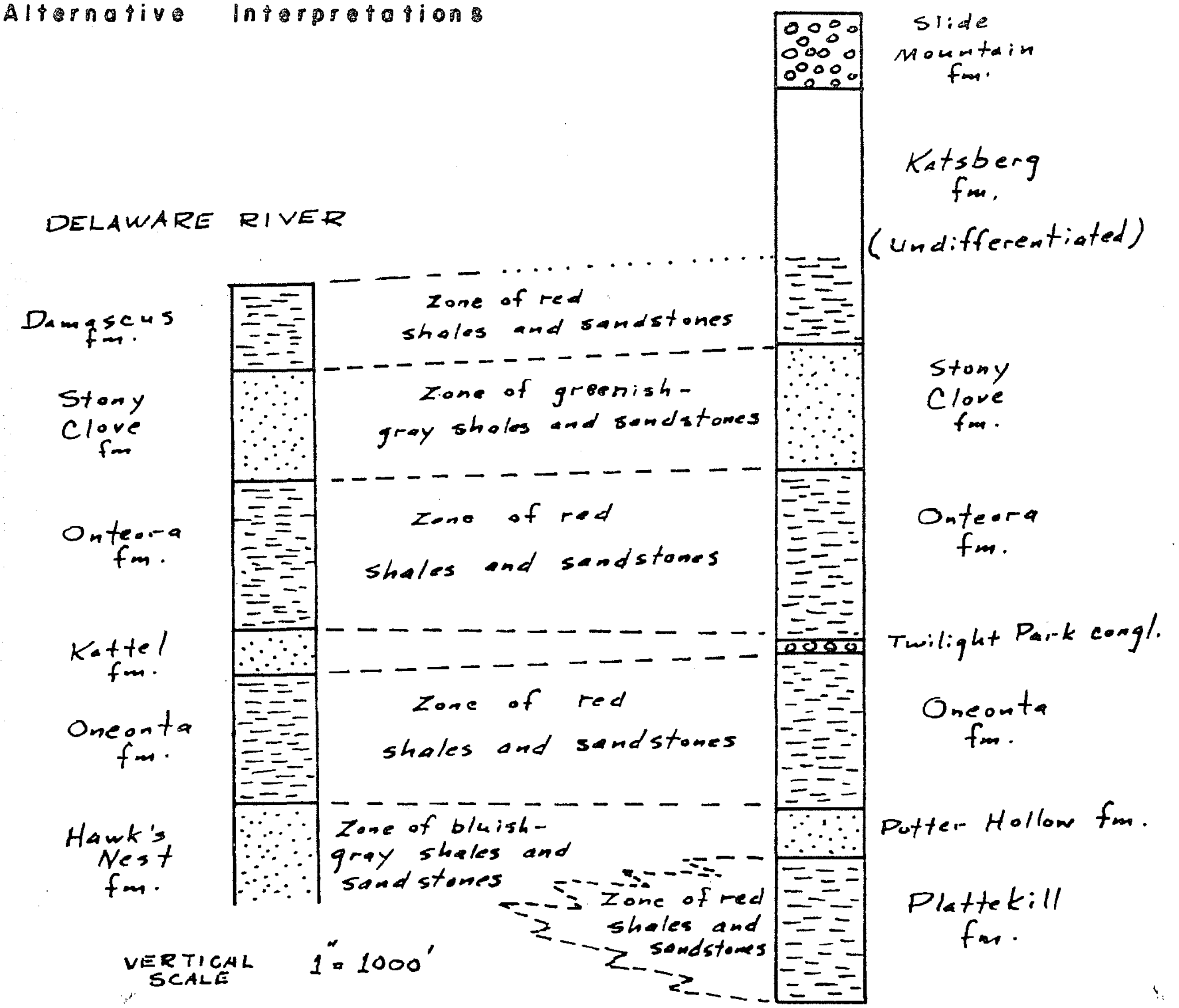


PLATE III

CORRELATION CHART

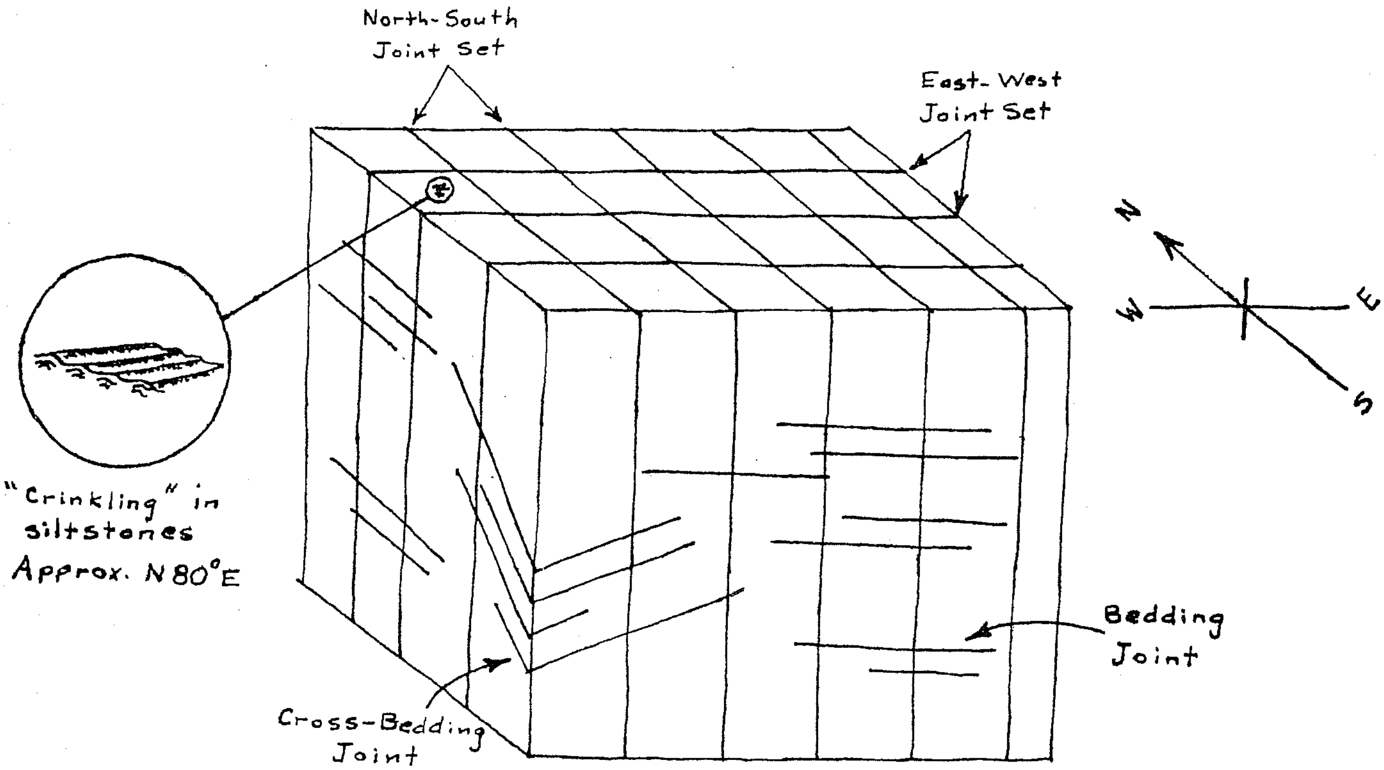
Alternative Interpretations



Delaware River		Catskill Front		Western & Central New York	
Willard 1936	Fletcher	Chadwick 1944	Fletcher		
		Slide Mountain	Slide Mountain		West Falls group
Honesdale		Katsberg	Katsberg		
Damascus	Damascus				
	Stony Clove	Stony Clove	Stony Clove	Rhinestreet	
Shohola	Onteora	Onteora	Onteora	Cashaqua	Sonyea group
	Kattel	Twilight Park	Twilight Park	Middlesex	
Delaware River	Oneonta	Kaaterskill	Oneonta	Ithaca	Genesee gr.
	Hawk's Nest	Kiskatom	Potter Hollow	Moscow	Hamilton gr.
——	"Hamilton"		Plattekill	Ludlowville	

PLATE IV

TECTONIC STRUCTURES



SEDIMENTARY STRUCTURES

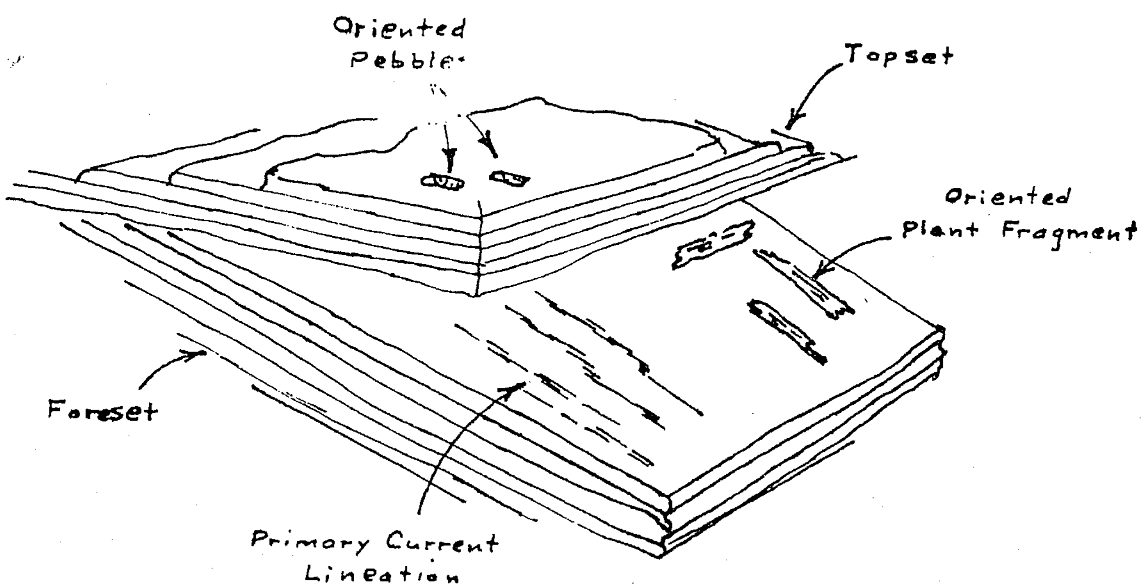
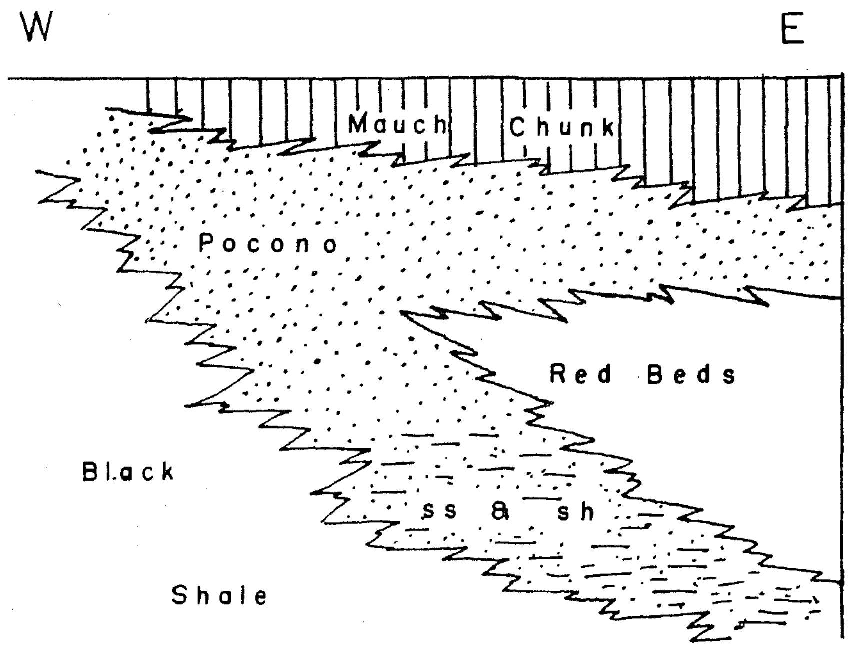


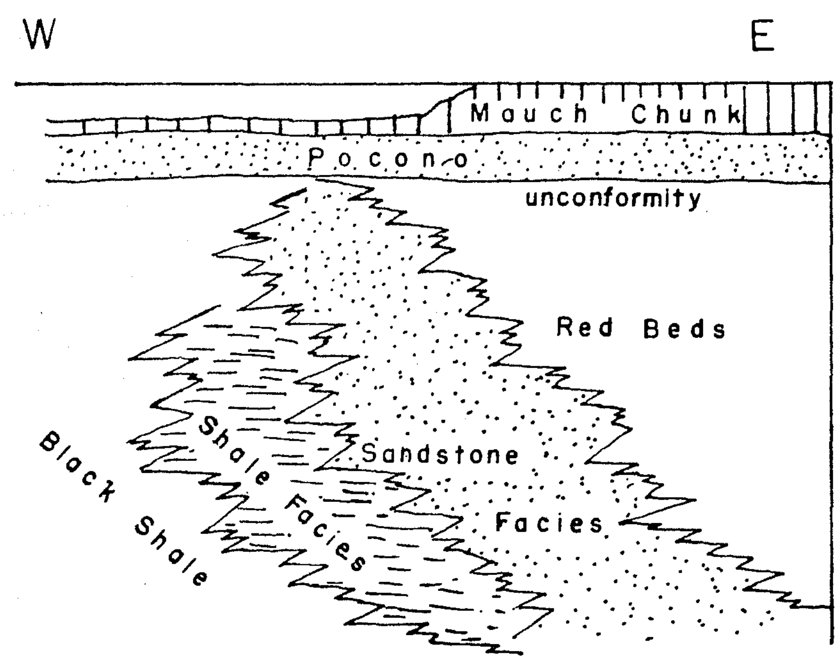
PLATE V

PLATE VI

ALTERNATIVE INTERPRETATIONS OF THE POCONO-CATSKILL CONTACT



(Suggested by Weller, 1960, Stratigraphic Principles and Practices, Harper Bros., p. 399, fig. 156.)



(Suggested by Ashley, 1938, Am. Assoc. Petroleum Geologists Bull., v. 22, p. 422, fig. 5.)

PLATE VII

MARINE - NONMARINE FACIES RELATIONSHIPS