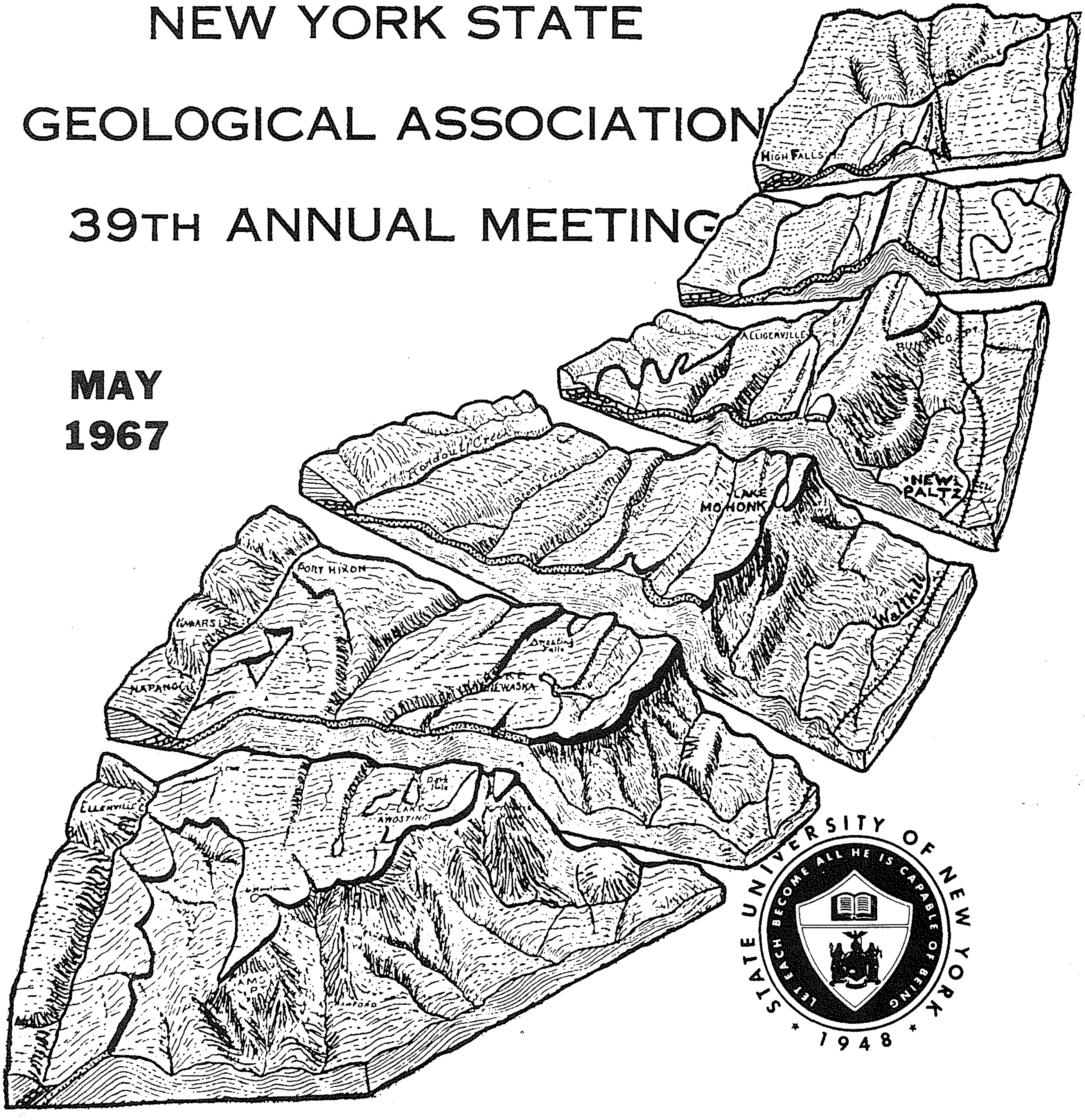
GUIDE BOOK

NEW YORK STATE

GEOLOGICAL ASSOCIATION

39TH ANNUAL MEETING

MAY
1967



STATE UNIVERSITY OF NEW YORK
LET EACH BECOME ALL HE IS CAPABLE OF BEING
1948

S.U.N.Y. COLLEGE AT NEW PALTZ

DIVISION OF PHYSICAL SCIENCES

NEW YORK STATE GEOLOGICAL ASSOCIATION

39th ANNUAL MEETING

May 5 - 7, 1967

GUIDE BOOK TO FIELD TRIPS

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Russell H. Waines

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Additional Copies of this Guide Book are available for the permanent secretary of the New York State Geological Association: Dr. Kurt E. Lowe, Department of Geology, City College of the City University of New York, 139th Street at Convent Avenue, New York, N.Y.

Acknowledgements

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The New Paltz Geological Society, among other things, has assisted by supplying road guards for the Field Trips.

Finally, thanks are due the administration of the State University of New York College at New Paltz for uses of many facilities in preparation for the meetings and for general support of this endeavor.

To all these and more the Guide Book and Annual Meeting owe whatever approbation is deserved.

Russell H. Waines

Editor

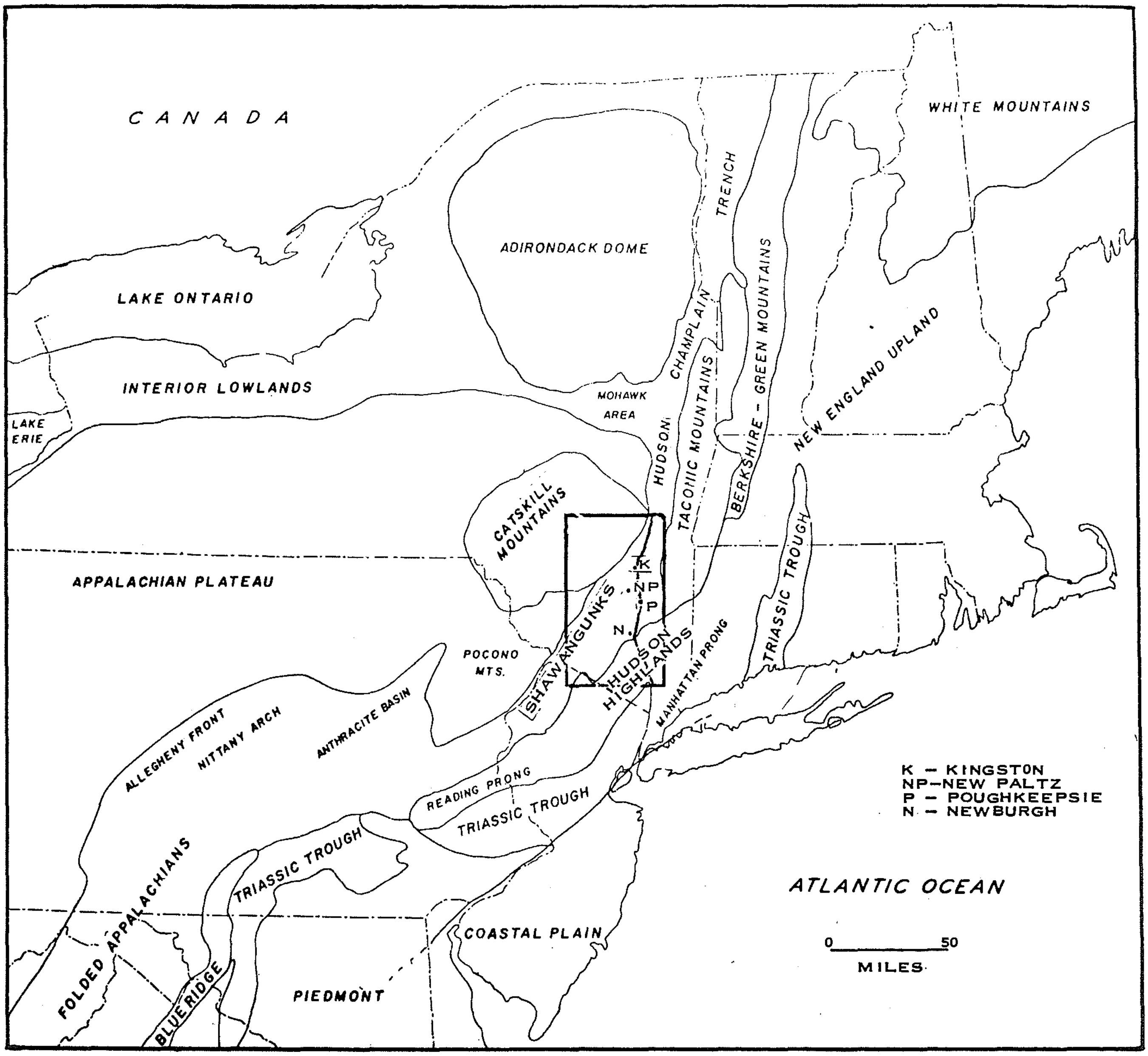
P.S. For the most part, changes in original manuscripts where minor. For the few other alterations made without consultation (because of time) the editor is, of course, responsible.

TABLE OF CONTENTS

MAGNA CONTENTIO MINUS VALET

QUAM EXEMPLA OBSERVATA

COVER ILLUSTRATION ADAPTED FROM
N. H. DARTON, 1894A, PL.12 STEREOGRAM OF THE SHAWANGUNK MOUNTAIN



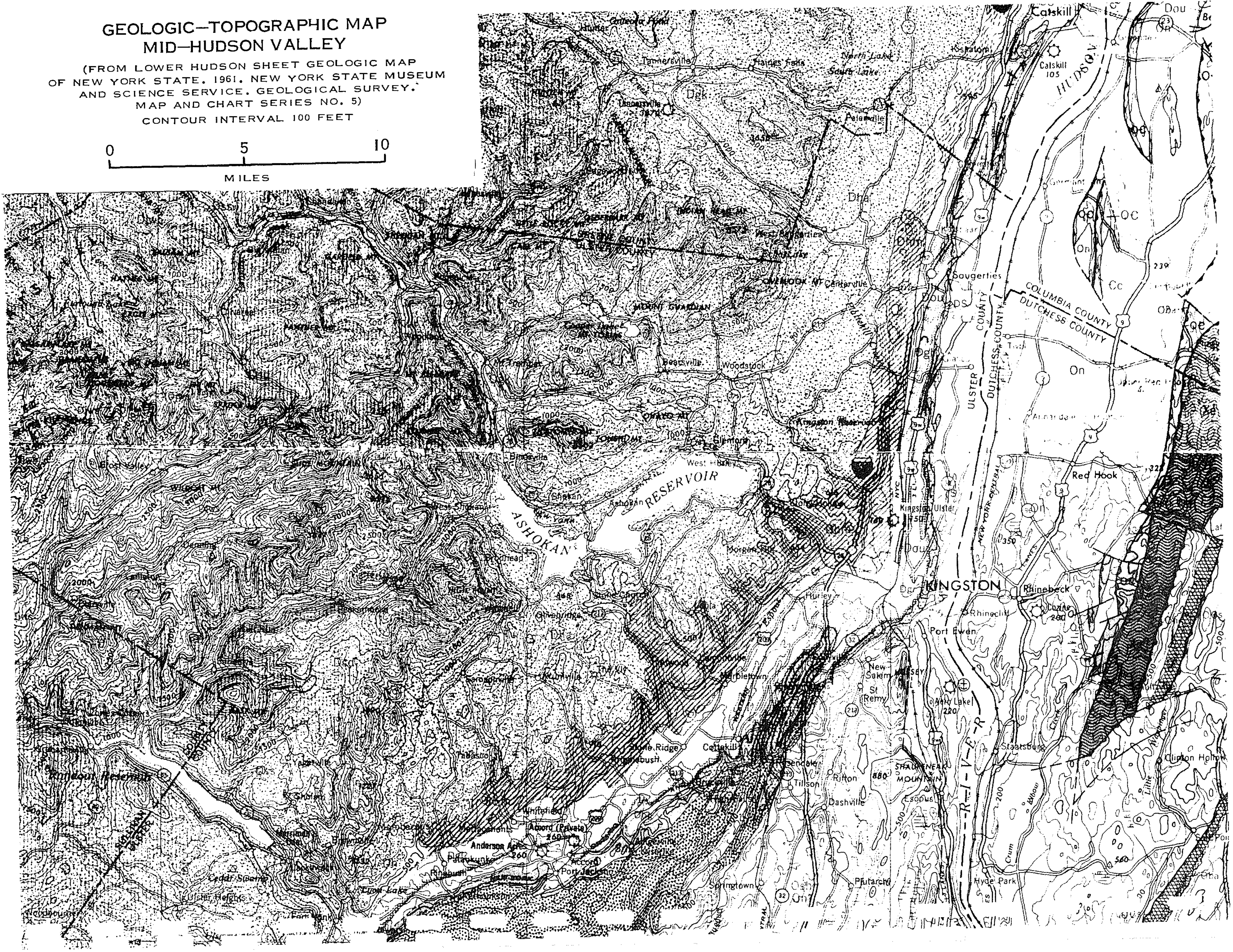
REGIONAL SETTING OF GEOLOGIC MAP
AND
FIELD TRIP AREA
(NYSGA 1967 MEETING)

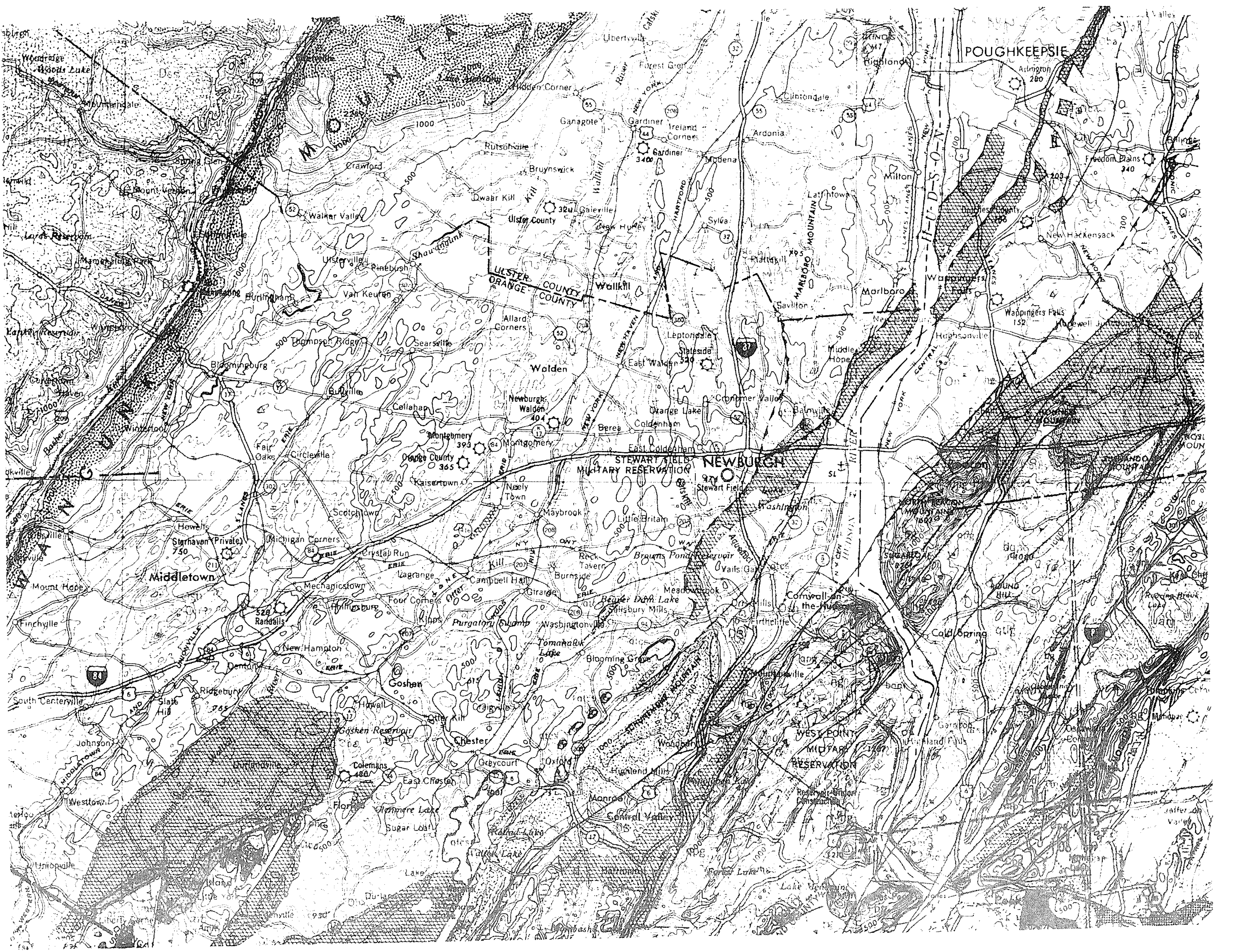
(Adapted from H. A. Meyerhoff, 1963, in NYSGA Guide Book 35th Ann. Meeting, p. 17, fig. 1)

GEOLOGIC–TOPOGRAPHIC MAP
MID–HUDSON VALLEY

(FROM LOWER HUDSON SHEET GEOLOGIC MAP OF NEW YORK STATE. 1961. NEW YORK STATE MUSEUM AND SCIENCE SERVICE. GEOLOGICAL SURVEY. MAP AND CHART SERIES NO. 5)

CONTOUR INTERVAL 100 FEET




POUGHKEEPSIE
NEWBURGH
HUDSON
RIVER
STEWART FIELD
MILITARY RESERVATION
WEST POINT
MILITARY
RESERVATION
ULSTER COUNTY
ORANGE COUNTY
MARLBORO MOUNTAIN
Middletown
Walden
Goshen
Chester
Montgomery
Wallkill
Marlboro
Milton
Highland
Gardiner
Ardonia
Modena
Clintondale
Ganagote
Rutsonville
Bruynswick
Crawford
Walker Valley
Pine Bush
Ulsterville
Van Keuren
Allard Corners
Searsville
Thompson Ridge
Bloomingburg
Bullville
Cellahan
Circleville
Fair Oaks
Scotchtown
Kaisertown
Neely Town
Maybrook
Little Britain
Rock Tavern
Burnside
Campbell Hall
Lagrange
Crystal Run
Michigan Corners
Howells
Mechanicstown
Phillipsburg
Four Corners
Kipps
Washingtonville
Salisbury Mills
Blooming Grove
New Hampton
Denton
Ridgebury
Slate Hill
South Centerville
Johnson
Westtown
Unionville
Finchville
Mount Hope
Randalls
Howell
Otter Kill
Greycourt
Oxford
Monroe
Central Valley
Highland Mills
Woodbury
Mountainville
Cornwall-on-the-Hudson
Vails Gate
Cold Spring
Fishkill
Wappingers Falls
New Hackensack
Hughsonville
Freedom Plains
Arlington
Balmville
Middle Hope
Savilton
Plattekill
Lattintown
Sylva
New Hurley
Galeville
Leptondale
East Walden
Stateside
Orange Lake
Coldenham
East Coldenham
Berea
Cronomer Valley
Purgatory Swamp
Tomahawk Lake
Beaver Dam Lake
Browns Pond Reservoir
Goshen Reservoir
Glenmere Lake
Sugar Loaf
Colemans
East Chester
Florida
Orange County
365
Sterhaven (Private)
750
Newburgh Walden
404
Dwaar Kill
Shawangunk
Winterton
Woodridge
Spring Glen
Mount Vernon
Ellenville
Lake Minnewaska
Hidden Corner
Forest Glen
Ubertyville
Ireland Corners
Stewart Field
Washington Lake
Aqueduct
Round Hill

EXPLANATION OF ROCK TYPE SYMBOLS
GEOLOGIC MAP OF MID–HUDSON VALLEY

Middle Devonian

- Djws Slide Mountain Formation - red shale, sandstone, conglomerate.
- Dsd Lower Katsberg Formation - sandstone, red shale, siltstone.
- Dss Stony Clove Formation - sandstone, conglomerate, shale.
- Dgk Oneonta Formation - red shale, sandstone; Kaaterskill sandstone.
- Dh Undifferentiated Hamilton Group - shale, siltstone.
- Dha Kiskatom Formation - red and green shales, sandstone; Ashokan Formation - sandstone, shale.
- Dhm Lower Hamilton group-shale, siltstone.

Lower Devonian

- Dou Onondaga Limestone; Schoharie Formation - shale, limestone, sandstone; Esopus Shale.
- Dgl Glenerie Formation - siliceous limestone, chert.
- Dhg Helderberg Group - limestones and dolomite.
- Ds Helderberg Group and undifferentiated Silurian Rocks.

Upper Silurian

- Srh Rondout Formation - dolomite, limestone; Decker Ferry Limestone; Binnewater Sandstone; High Falls Shale.

Middle Silurian

- Ssk Shawangunk Formation - sandstone, conglomerate.

Middle Ordovician

- Osh Trenton Group (black shales); Snake Hill Shale.
- On Trenton Group (Taconic Area); Normanskill Formation; Austin Glen Member - graywacke, black and gray shales; Mount Merino Member - black shale and chert; Indian River Member - red and green slate.

Ordovician and/or Cambrian

- O€s Stockbridge Group - undifferentiated carbonates.
- €1 Stissing Limestone; Winooski, Mellett and Dunham Dolomites; Monkton Quartzite.

Lower Paleozoic and/or Precambrian (positioning is arbitrary)

- am Hornblende gneiss, amphibolite, pyroxenic amphibolite, biotite granitic gneiss, migmatite, subordinate calc-silicate rock.
- amg Interlayered hornblende granitic gneiss and amphibolite.
- bg Biotite granitic gneiss; overprint signifies inequigranular texture.
- bhg Biotite hornblende granite.
- bqpc Biotite-quartz-plagioclase paragneiss with subordinate biotite granitic gneiss, amphibolite, and calc-silicate rock.
- hg Hornblende granite and granitic gneiss, with subordinate leucogranite.
- mb Calcitic and dolomitic marble, variably siliceous; in part with calc-silicate rock and amphibolite.
- mu Undivided metasedimentary rock and related migmatite.
- mug Interlayered granitic gneiss and metasedimentary rock.
- qpg Quartz plagioclase gneiss; may contain pyroxene, hornblende, biotite, locally interlayered with amphibolite.
- qtcs Non-rusty paragneiss: includes garnet-biotite-quartz-feldspar gneiss, quartzite, quartz-feldspar gneiss, calc-silicate rock.
- qtlg Garnet-bearing leucogranitic gneiss interlayered with quartzite containing varying amounts of biotite, garnet, sillimanite; minor marble, amphibolite, rusty paragneiss.
- rg Rusty paragneiss: includes biotite-quartz-plagioclase paragneiss, marble, calc-silicate rock; pyrite and graphite are characteristic.

Cortlandt Complex: Xban, biotite augite norite; Xd, diorite with hornblende and/or biotite, Xhn, hornblende norite; Xopx, olivine pyroxenite; Xpx, pyroxenite.

- Xm Manhattan Formation; schistose gneiss with local interlayers of amphibolite; marble.
- Xi Inwood marble; locally with quartzite at base.

UNUSUAL FEATURES OF THE NEW YORK SECTOR OF THE APPALACHIAN MOUNTAINS

JOHN RODGERS
Yale University

New York State's peculiar shape provides it with a complete cross-section of the Appalachian chain, from the Atlantic Coastal Plain in Long Island to the Central Lowlands of the continent around the Great Lakes. Partly this is because the Appalachians are unusually narrow in New York, even when one includes the Appalachian Plateau, whose northeastern extremity is the Catskill and Helderberg Mountains. The narrowness in turn results from a pronounced recess in Appalachian trends between two great salients, one in central Pennsylvania and one in southeastern Quebec and adjacent New England. This is not the only recess in the Appalachians, though it is one of the best developed; others are well-exposed around Roanoke, Virginia, and Rome, Georgia, or are hidden under the Gulf of Saint Lawrence or beneath the Gulf Coastal Plain in Alabama and Mississippi. All these recesses seem to be angular, in contrast to the smoothly arcuate curves of the intervening salients. Furthermore, the angles seem to be formed by intersecting trends of fold axes or other structural features.

Within the New York recess, the trends appear to outline two separate angles: one from about N 65 E to about N 35 E at and southeast of the Delaware Water Gap; the other from about N 40 E to about N 10 E at and southeast of Kingston, New York. These angles are well shown in the trends and boundaries of the Valley and Ridge province which continues northeast from the Great Valley of Pennsylvania and New Jersey to include the Wallkill and middle Hudson Valleys in New York State and the adjacent Shawangunk and Schunemunk Mountains. The province narrows northeastward and finally seems to disappear south of Albany. (On the northern border of the Appalachian Plateau province, on the other hand, the recess seems to be displaced eastward to the vicinity of Albany, where the border intersects the Appalachian trends almost at right angles; however, the angle there is produced more by the southeastward projection of the Canadian shield into the Adirondack Mountains than by changes in Appalachian fold trends.)

Southeast of the Valley and Ridge province is the line of Precambrain basement "Highlands" anticlinoria that extends from the Reading Hills of eastern Pennsylvania to the Green Mountains of Vermont; the New York representative is the Highlands of the Hudson. The trends of these anticlinoria also outline the New York recess and its two subordinate angles: a blunt angle near the Delaware River, and a deep reentrant in western Connecticut between the general east-west trend of the Hudson Highlands crossing the New York border and the general north-south trend of the Berkshire Highlands crossing the Massachusetts border. This reentrant is an unusual feature for it is only slightly larger than a right angle and is sharper than any other observable angle along the Appalachians between the Gulf of Saint Lawrence and the Gulf Coastal Plain. It is almost exactly centered between the west end of the Reading Hills and the north-plunging end of basement outcrops in the Green Mountains — 275 kilometers (180 miles) from each. In addition, the anticlinoria seem to rise higher and higher toward the reentrant, so that one might expect the Precambrian belt to be highest and broadest there. In fact, however, the reentrant is marked by a 50-kilometer (30-mile) gap between the Hudson and Berkshire Highlands. The gap flares northwestward and is filled mainly with metamorphosed lower Paleozoic rocks. Because the isograds are not affected by the reentrant but strike about N 25 E across it, the Paleozoic rocks show a complete gradation from virtually unmetamorphosed on the northwest to sillimanite-grade in the throat of the gap. This is the locality of the well-known study of progressive metamorphism by Barth and Balk. Some Precambrian blocks are also exposed within the gap: Stising Mountain far to the northwest, the Housatonic Highlands on the New York-Connecticut border, and perhaps others still deeper, where Paleozoic metamorphism has obliterated the metamorphic contrast between basement and Paleozoic rocks.

The Precambrian anticlinorial cores are certainly uplifted relative to the Valley and Ridge province, probably by several kilometers, and in accordance with the characteristic Appalachian asymmetry the uplift was accompanied by relative northwestward movement. In the Green Mountains anticlinorium of Vermont and the South Mountain or Blue Ridge anticlinorium of south-central Pennsylvania, Maryland, and northern Virginia, this northwestward movement was apparently rather moderate, associated only with the formation of the asymmetrical anticlinoria and with a few discontinuous thrust faults on their oversteepened limbs. Elsewhere, however, evidence is accumulating for recumbent folding involving large-scale horizontal transport. The case is now clearest in Pennsylvania, where the whole southeast side of the Great Valley from the Susquehanna to the Delaware has been shown to be the complex middle limb of a giant recumbent fold pair, and gravity data strongly support the interpretation that the Precambrian rocks of the Reading Hills and their eastward extension are the floating basement core of the anticlinal member of the pair. Similarly, Ratcliffe's recent work in western Massachusetts suggests that the Berkshire Highlands are also completely recumbent, overturned on the Paleozoic rocks to the west.

To what extent the same overturning and recumbency has occurred in New York State is unknown; the northwest side of the Hudson Highlands has generally been interpreted as a high-angle reverse fault, although floating blocks of Precambrian basement are known northwest of it. One might suggest instead that some of the high-angle faulting is (Triassic?) normal faulting, down-dropping the Precambrian rocks in the core of the recumbent anticline beside the Paleozoic of the underlying middle limb. One might further suggest that the horizontal displacement involved in the recumbent fold is measured by the depth of the western Connecticut reentrant in the line of anticlinoria — nearly 40 kilometers (25 miles). Indeed, the recess is possibly the locus of maximum overturning and horizontal transport in the entire region from western Massachusetts to eastern Pennsylvania.

Another unusual feature of the New York sector of the Appalachians is the Taconic slate mass which lies entirely on the north side of the New York recess. This mass has been the subject of controversy for well over a hundred years because, although its apparent stratigraphic and structural position above surrounding Middle Ordovician carbonate rocks demands a Middle or Late Ordovician age, it contains fossils ranging back to Early Cambrian. However, this mass no longer seems as unusual as it used to; similar masses now recognized from Newfoundland to the Susquehanna River have raised the same problems and have evoked the same answers, *i.e.*, either rapid facies changes in restricted basins surrounded by carbonate shelves or allochthonous thrust sheets or slide masses from another facies realm to the east (either stratigraphic complexity and structural simplicity or vice versa). Comparison with allochthonous slide masses elsewhere, notably in the Alpine chains of Morocco, Italy, and other Mediterranean countries, has convinced many of us of the truth of the latter answer, but I doubt if the debate is over.

The northern and central Appalachian arcs on either side of the New York recess seem to have had rather different orogenic histories. In the central (and southern) Appalachians, the obvious deformation, as in the Appalachian Plateau and Valley and Ridge provinces, is late Paleozoic, post-Pennsylvanian and perhaps post-Early Permian. Recently, however, stratigraphic, tectonic, and radiometric evidence for older orogeny has slowly been accumulating, suggesting major deformation also in the early Paleozoic, probably in the Ordovician for the most part. The extent of this orogeny southwest of

New York is still quite uncertain, except that it affected mostly the Piedmont region on the southeast side of the chain. In the central and southern Appalachians, therefore, orogeny seems to have migrated northwestward toward the interior of the continent, at least during the Paleozoic. In the northern Appalachians, on the other hand, evidence of multiple deformation is abundant and has long been known: the late Paleozoic deformation, though present, is confined to the southeast side; the early Paleozoic deformation is most obvious along the northwest side; and the most widespread and most intense period of orogeny was middle Paleozoic, largely Devonian. Thus, orogeny here generally migrated away from the continent. The relative unimportance of the late Paleozoic deformation in the northern Appalachians is a reason, I believe, for refusing it the title Appalachian Orogeny or Revolution. I prefer to call it by Woodward's term "Alleghany orogeny", so that it can take its proper place beside the Acadian and Taconian among the Appalachian orogenies, of which the roster is probably not yet complete.

Situated between these two different arcs, the New York recess should contain evidence of multiple orogeny, and it does. A Precambrian ("Grenville") orogeny is represented by the contrast between the igneous and metamorphic basement and the overlying sedimentary Paleozoic rocks. The Taconian orogeny is represented by the angular unconformity between the Middle Ordovician and the Silurian along Shawangunk and Schunemunk Mountains on either side of the Wallkill Valley; on the Shawangunk side the Silurian rocks have not overstepped the Middle Ordovician, but on the Schunemunk side they overlap onto the Precambrian. In the absence of Carboniferous rocks anywhere between the Lackawanna syncline in northeastern Pennsylvania and the Narragansett basin in central Rhode Island (except for some granite intrusions in southwestern Rhode Island and southern Connecticut), the Acadian and Alleghany orogenies cannot be clearly distinguished in the New York recess, but both are certainly present in Rhode Island and probably, to judge by radiomentry, in Connecticut and the Manhattan prong.

The intersecting trends in the New York recess may provide further clues for unscrambling the effects of the different orogenies. Presumably the trends coming up the northwest side of the Valley and Ridge province out of Pennsylvania must be Alleghany, at least those of the folds in the anthracite basin and their continuations. Evidence in Pennsylvania suggests, on the other hand, that the great recumbent folds on the southeast side of the Great Valley are pre-Silurian, i.e. Taconian, and the rapid overlaps of the Silurian strata around Schunemunk Mountain and its southwestward continuation in New Jersey can be interpreted in the same terms. (Indeed, Ratcliffe in western Massachusetts reports evidence for recumbent folding of Lower Ordovician rocks before the deposition of Middle Ordovician.) On the other hand, the broader trends of the northern Appalachians are Acadian, certainly for some distance west of the Connecticut River and quite possibly all the way to the Hudson. Very probably the folding in the Silurian and Devonian west of the Hudson, north of the angle at Kingston, is also of this age, but whether the corresponding folds between Kingston and the Delaware Water Gap are Acadian or Alleghany is still debatable. Their trend is also that of the high-angle faults in the New York and New Jersey Highlands; these faults may well be Triassicin part, but as W.M. Davis showed long ago in Connecticut, Triassic faults tend to follow pre-existing strikes. It is even possible that these trends were first marked out in the Taconian orogeny, the western limit of which must trend from Albany to eastern Pennsylvania, well to the west of the eastern edge of the overlapping Silurian and possibly just east of the abrupt eastern termination of the folds in the anthracite basin and along the aberrant trend of the Lackawanna syncline.

To summarize, the New York sector of the Appalachians is unusual because it includes much of a major recess in the chain, notable (like other Appalachian recesses) for the angular intersection of structural trends and also for extreme horizontal transport along the northwest margin of the chain's metamorphic core. Moreover, the angularity may have been produced by the overlapping and crossing of orogenic trends produced at several different times in the Paleozoic. Probably the first geologist to emphasize the angularity was Arthur Holmes, who used it as an argument for continental drift, for he saw the westward convergence of Caledonian and Hercynian trends in the British Isles finally completed by their crossing in the New York recess, where, as noted above, the polarity of orogenic migration during the Paleozoic reverses.

THE PLEISTOCENE GEOLOGY OF THE WALLKILL VALLEY

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LESLIE A. SIRKIN
Adelphi University

GENERAL GEOMORPHOLOGY

The Wallkill Valley is a northeast-southwest trending basin approximately 65 miles long and 20 miles wide, narrowing to the south. The western boundary of the valley is the scarp of the Shawangunk Mountain cuesta. The eastern boundary is the dip slope of the Marlboro Mountain hogback on the north, and the fault line scarp of the Hudson Highlands on the south. The valley heads in northern New Jersey in the glacial drift north of the Ogdensburg - Culvers Gap Moraine and opens into the Rondout Creek Valley between Rosendale and Kingston, New York (Fig. 1).

The lowest point in the valley is at an elevation of 140 feet at the confluence with Rondout Creek; however, most of the valley floor lies between 200 and 400 feet. The highest point on the western divide is 2289 feet at Sam's Point giving the valley a total relief of over 2000 feet. The eastern divide is breached by several east-west valleys, the most prominent of which separates the Marlboro Mountains from the Hudson Highlands and is drained by Moodna Creek. The highest point on the eastern divide is 1129 feet on Illinois Mountain, east of Highland.

BEDROCK

The valley is underlain by rocks of the Martinsburg Formation of Ordovician age. Although the names 'Hudson River Formation', 'Snake Hill Shale', and 'Normanskill Formation' appear in various publications, no criteria for correlation have ever been applied and the more general name used by McBride (1962) seems preferable.

The Martinsburg is buttressed by the overlying, very competent, Shawangunk conglomerate on the west, accounting for the oversteepened Shawangunk Mountain escarpment. East of the Shawangunks the Martinsburg is an incompetent, thin-bedded, easily eroded shale with many structural complications. Further east, in the vicinity of the Marlboro Mountains the Martinsburg contains thicker-bedded, more competent graywackes similar to the Austin Glen Formation to the north. The sandstone beds are resistant to erosion thus accounting for their topographic expression in the east valley wall. Graywackes, interbedded with shales, underlie most of the resistant strike ridges present east of the Wallkill River.

Near Newburgh and Montgomery, New York, and in northern New Jersey, Precambrian and Cambrian carbonate rocks crop out whereas the Hudson Highlands are composed of crystalline metamorphic rocks of Precambrian age. Southeast of Newburgh, Devonian clastic rocks are present on Schunemunk Mountain, a northerly plunging syncline.

PHYSIOGRAPHY

The entire valley lies within the Hudson-Mohawk province of New York State (Broughton, et al., 1962) or the Valley and Ridge province of Thornbury (1965).

The topography is dominated by northeast-trending hogbacks, roches moutinees, rock drumlins and drumlins. Although there is a thick cover of glacial drift in the valley, polished striated bedrock is common above 500 feet.

Stagnant ice topography is prevalent adjacent to the Shawangunks in the valley of Shawangunk Kill (Stop A-8) and adjacent to the Wallkill River channel (Stops A-3 to A-7 and G-2) but is not restricted to those areas.

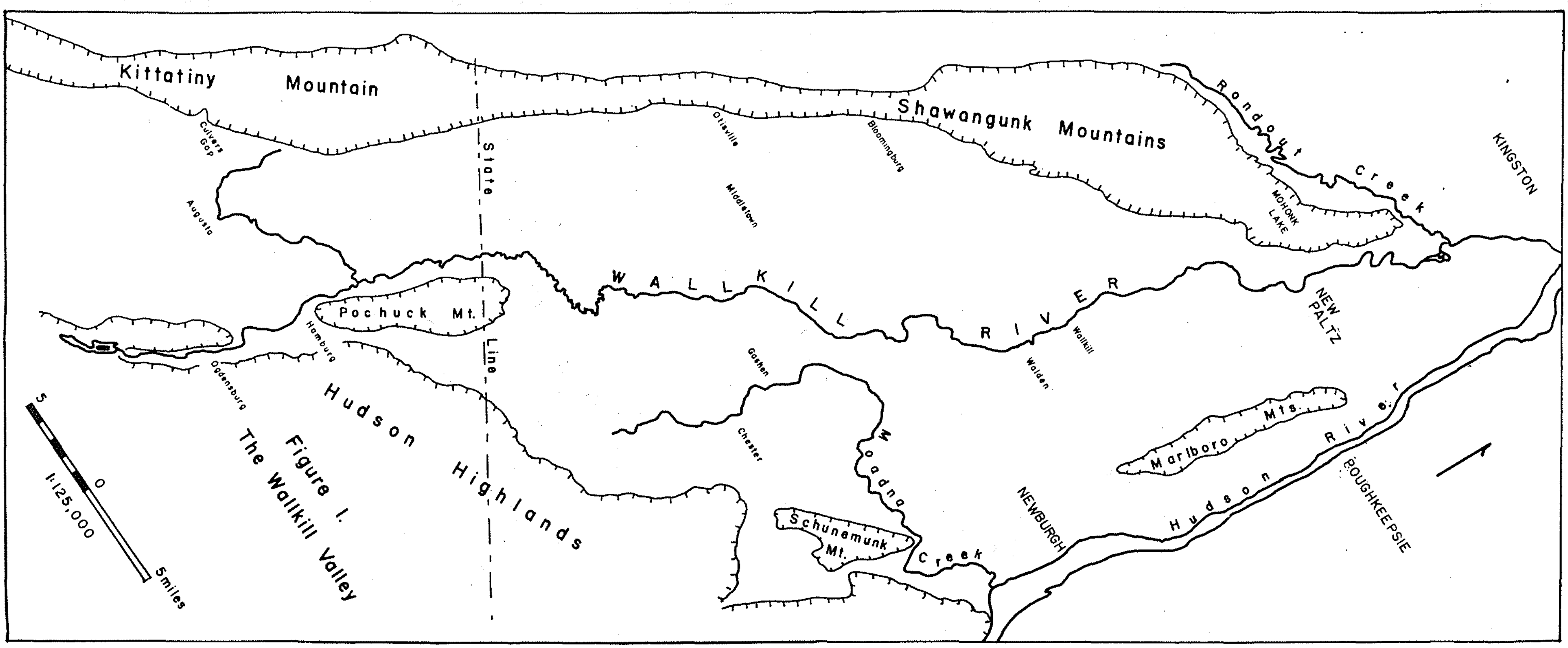

Figure I. The Wallkill Valley

Drainage patterns tend to be deranged. There are areas where a distinct parallel pattern is noted reflecting the underlying bedrock. However, where stagnant ice deposits are present, barbed deranged patterns are the rule. The numerous drainage reversals have made it quite difficult to reconstruct preglacial drainage with any degree of accuracy. Many swamps and bogs are present as a result of drainage reversals. Prominent examples are present near Chester (Stop A-1) and Pine Island (Stops A-2, A-3) where extensive muck farming has taken advantage of the thick organic deposits that have filled in remnants of proglacial lakes.

THE WALLKILL DRAINAGE NET

About 80% of the area is drained by the northerly flowing Wallkill River and its tributaries. The only other major stream system is the Moodna Creek - Otter Kill system that empties directly into the Hudson River south of Newburgh. The Wallkill drainage net has been studied by Howard (1967) and in many geomorphology class projects under the direction of the senior author. The hypsometric curve suggests that the Wallkill is in the monadnock stage of Strahler (1952) while the longitudinal profile (Fig. 2A) suggests an old age stream. According to Howard, the river is at grade for about 45 miles south of its headwaters, drops over a bedrock knickpoint and is again at grade for about 25 miles.

Many of the tributaries north of the knickpoint show hypsometric curves in the monadnock stage giving a classic picture of an old age stream. However, downstream from the knickpoint the tributaries show equilibrium or inequilibrium curves. In addition, the Wallkill has developed an extensive floodplain in its upstream reaches but has a relatively youthful appearance downstream from the knickpoint as it flows over a dissected lake plain rather than a floodplain.

Downstream from the bedrock knickpoint Berkey (1911) has reported a deep bedrock gorge, almost 100 feet below sea level. The senior author and M. Frimpter (personal communication) have searched for a preglacial gorge for the Wallkill south of the knickpoint and have concluded independently that it is absent. A preglacial channel is not encountered to the south except beneath the Orange County muck area where borings for the New York City Port Authority show bedrock about 100 feet below the surface. Figure 2B shows a possible preglacial profile reconstructed from meagre subsurface data.

It is here suggested that the upper Wallkill Valley, perhaps south of Walden, New York, occupies the valley of an ancestral, south-flowing stream while the lower Wallkill is reoccupying the valley of its north-flowing predecessor. The upstream ancestor was probably a stream in an advanced erosional stage whereas that downstream was probably an actively eroding, youthful stream. This tentative explanation accounts for the bedrock profile and for the apparent differences in erosional history between the upstream and downstream tributaries. The north-flowing ancestor was probably much more vigorous and was actively capturing drainage from the south-flowing ancestor: a situation similar to that at the Catskill front today.

Berkey's subsurface data for the Moodna Creek Valley suggest a similar reconstruction for the ancestral Moodna Creek channel.

GLACIAL DRIFT

To date, no direct evidence has been found in the Wallkill Valley that would indicate the presence of pre-Wisconsinan glaciations. Only the presence of "old drift" reported in New Jersey by Salisbury (1902) and Pennsylvania by Leverett (1934) testifies to older glaciation. Thus, the Wallkill Valley drift is probably all Wisconsinan.

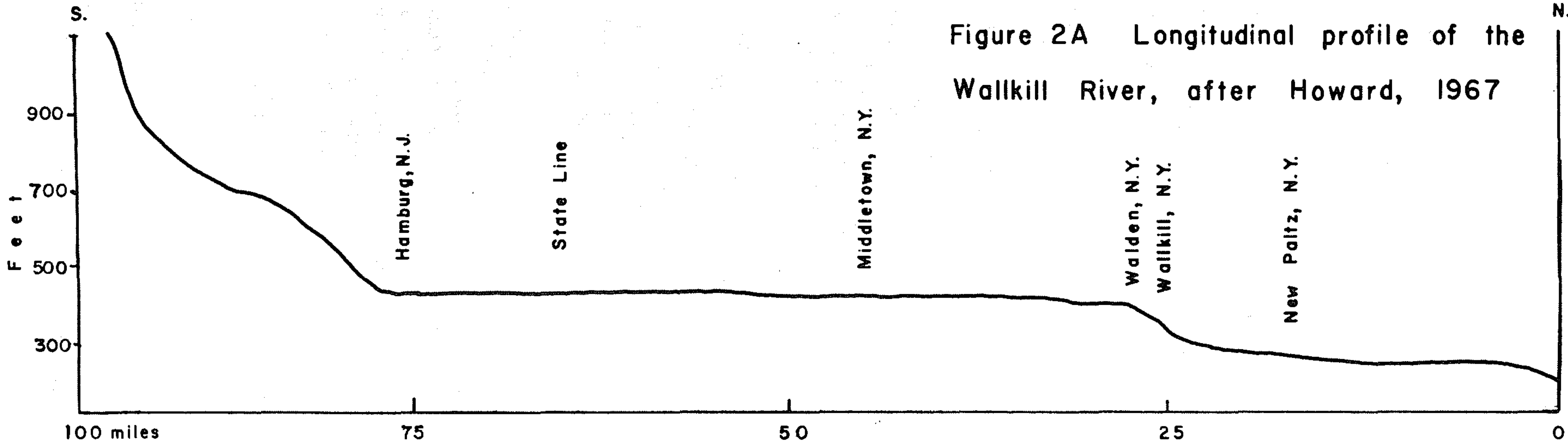

Figure 2A Longitudinal profile of the Wallkill River, after Howard, 1967

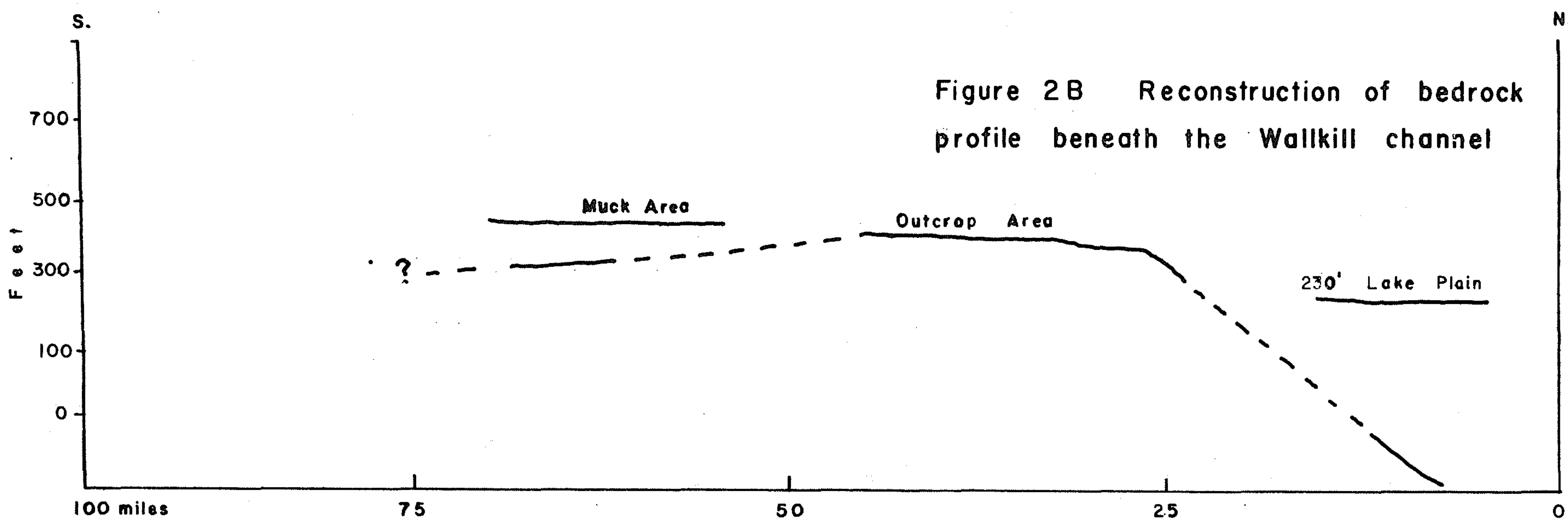

Figure 2B Reconstruction of bedrock profile beneath the Wallkill channel

TILL

Oxidized, leached, shale-clogged till is present as an almost continuous blanket over the whole region. If this is assumed to be the weathered equivalent of fresh till, then the till appears to be quite uniform throughout the region suggesting only a single glaciation. However, this till frequently contains pockets and lenses of washed stratified drift (Stop G-1), suggesting an origin as an ablation product rather than a weathering product.

Fresh unweathered till has been observed in few localities. It is firm, medium-light- to dark-gray, and has a loam to clay-loam matrix. It is sparsely stoney and only slightly calcareous. The stones are usually channers of more resistant sandstones from the Martinsburg Formation. Few crystalline rocks are present except immediately adjacent to the Shawangunk Mountains where white quartzite pebbles are relatively abundant. Insoluble residue studies performed on nine fresh till samples using 10% HCl showed only 4-8% total carbonate.

In the few exposures where a section is measurable (Stop A-2) beneath an undisturbed surface, the till is leached for 6-9 feet and oxidized for 16-18 feet. The oxidized till is usually light-olive-gray, but is similar to the fresh till in other properties. The leached till varies from light-brown to dark-yellowish-orange and has a powdery silt or silt-loam matrix in which shale particles prevail.

Frischman (1967) has examined the soils in the vicinity of New Paltz based on the subsurface work of Berkey (1911) and the soil types and associations reported by Sweet (1940). It appears that two soil associations have developed on the tills in the lower Wallkill: the Cossayuna and Hoosic associations. The Cossayuna soils tend to develop on compact lodgement till while the Hoosic soils develop on ablation tills (although they are described as developing from glaciofluvial sediments). Even though one would expect greater depth of soil development on the less compact ablation deposits, such is not the case. The Cossayuna soils seem to be at least as deep, and probably deeper, than the Hoosic soils, suggesting that the surface till in the lower Wallkill is ablation drift and is younger than the lodgement till. This hypothesis remains to be tested.

STRATIFIED DRIFT

The stratified drift is generally a shale gravel. Only in the extreme north (Stop G-5) and the east and southeast (Stop A-1) are appreciable amounts of other lithologies evident. An exception is the area adjacent to the Shawangunk escarpment (Stop A-8) where quartzite pebbles and boulders are abundant. The exotic lithologies in the eastern Wallkill resemble the metamorphic rocks of Dutchess and Columbia Counties, east of the Hudson River. No exotic lithologies are found west of the Wallkill Moraine (defined below) nor are any Shawangunk pebbles or boulders found to the east of these moraines.

Stratified drift defines all the ice-marginal positions in the Wallkill Valley. It is present as outwash on distal slopes (Stop A-3), as kame or kame terrace deposits within the moraines (Stop G-2), as extensive esker systems (Stops A-1, 4, 6 and 7), or as massive crevasse fillings (Stops A-5 and 8).

The ice channel fillings present in the Wallkill River channel and the Ancestral Moodna Creek channel can be used to reconstruct a complex system of drainage within or around massive blocks of stagnant ice left in the lowlands (as originally inferred by Adams, 1934). The dominant transport direction was southward into a proglacial lake present at an elevation of 500 feet. Although these ice channels carried outwash deposits from the ice, inwash eskers are also present and evidently carried materials from the uplands onto the ice. Massive kames (?) (Stops A-6 and 7) mark the intersections of the inwash eskers with the major outwash channel. The role of the transverse crevasses is unclear (discussion at Stop A-5).

PROGLACIAL LAKE SEDIMENTS

Lake sediments, in the form of stratified sands (Stop G-3) and laminated silts and clays (Stop G-5), are present in many places in the southeastern part of the Valley. In the northwest these are restricted to the central Wallkill Valley below 230 feet. Organic deposits represent the final stages of fill in proglacial lakes and/or drainageways.

GLACIAL ADVANCE

Glacier movement in the Wallkill Valley can be inferred from streamlined landforms, abundant striae, drift lithology, and the morainal configuration. Salisbury (1902) reconstructed probable flow lines on the basis of similar data that tend to reflect the major elements or pre-existing topography. All data compiled for the Wallkill Valley tend to support the conclusions of Salisbury, summarized by his Plate VIII; similarly, data of Peltier (1939) east of the Hudson supported these conclusions.

Glacier movement in the Wallkill Valley was from the northeast to southwest, paralleling the strike of the Shawangunk Mountains and Hudson Highlands. These major topographic elements obviously channeled glacial flow although the Marlboro Mountains were probably an inhibiting factor. Most streamlined hills in the region, whether of drift or bedrock, tend to parallel this direction, even though it does not always coincide locally with bedrock strike.

STRIAE

Striae in the Valley are aligned parallel or subparallel to the major topographic elements. They tend to diverge somewhat from slightly west of north near the Marlboro Mountains to strongly northeast at the base of the Shawangunks. This suggests a lobate ice front with flow directed normal to the terminus rather than parallel to the main axis. The distribution of morainal belts is consistent with this interpretation.

Exceptions are noted near the Marlboro Mountains where northeasterly striae, either alone or associated with northwesterly striae, suggest movement from the Hudson trough over the mountains and into the Wallkill Valley.

Between the Marlboro Mountains and the Hudson River, and on the east bank of the Hudson, landforms are aligned north-south and striae range from north-south to slightly northeast (Gordon, 1911). Further east the trend is northwesterly according to Peltier (1939), suggesting a lobate ice front in the Hudson trough also.

From the orientation of striae in the vicinity of the Marlboro Mountains and from exotics present in the drift in the eastern Wallkill Valley it appears that two lobes were present in the Valley. It is suggested that a Wallkill Valley lobe was present from the Shawangunks to the uplands east of the Wallkill River while a spillover from the Hudson Valley lobe was present further east.

From the alignment of ice-marginal features proximal to the Shawangunks, striae in northwestern New Jersey, and the distribution of drift in the Minisink Valley west of the Shawangunks, it appears that a third lobe was present west of the Wallkill Valley. This lobe apparently flowed parallel to the axis of the Minisink Valley and thus paralleled the Wallkill Valley lobe. However, confluence of these two lobes is suggested locally in New Jersey and north of New Paltz. Howard (1966) has shown that the Wallkill Valley lobe split into two lobes, the main Wallkill lobe and the Minisink lobe, in the vicinity of Lake Mohonk near the northern end of the Shawangunk Mountains.

MORAINES

Although eight ice-front positions were originally reported in the Wallkill Valley (Connally, 1966), only six are recognized at present (Fig. 3). The two southernmost positions were mapped originally by Salisbury (1902) in New Jersey as the Culvers Gap and Augusta Moraines. The northernmost has not been mapped as yet but is inferred at Rosendale damming a 230 foot lake stage.

NEW JERSEY MORAINES

Herpers (1961) renamed the Ogdensburg-Culvers Gap Moraine and traced it continuously across the Valley. Minard (1961) has traced both the Ogdensburg-Culvers Gap and Augusta Moraines over the Kittatiny Mountains into the Delaware River Valley. Minard (personal communication) has also traced the Ogdensburg-Culvers Gap Moraine eastward into the Hudson Highlands using air photos.

It appears that the Augusta Moraine can be traced eastward to the kames at Hamburg, New Jersey and then northward to the State line where it is banked against the Hudson Highlands. The moraine has been tentatively traced about 10 miles northward to the west flank of Schunemunk Mountain where it is lost as it enters the rugged topography of the Highlands.

The close association of the two New Jersey moraines suggests a possible correlation with the two ice front positions of the Croton-Haverstraw stage of Woodworth (1905).

PELLETS ISLAND MORAINE

A third moraine is evident as a massive ridge of till and stratified drift athwart the Wallkill Valley two miles south of Goshen. This moraine is here named the Pellets Island Moraine for an exposure in the Orange County Sand and Gravel Co. pit (Stop A-3) at Pellets Island. The Pellets Island Moraine is almost continuously tracable eastward to Chester where it enters the Highlands in the vicinity of Schunemunk Mountain. This moraine probably is correlative with the moraine west of Otisville and with drift at Cuddebackville in the Minnisink Valley. When the glacier front had retreated to the Pellets Island position meltwater was forced southward forming a 500 foot lake.

NEW HAMPTON MORAINE

A fourth moraine is also referable to the 500 foot lake stage and is therefore probably closely associated with the Pellets Island Moraine. This moraine is here named the New Hampton Moraine for the belt of kames south of the New Hampton Training School, north of the Pellets Island Moraine. The New Hampton Moraine is well developed from south of Middletown to the village of Goshen. From Goshen north it has been obliterated by drainage from younger lake waters but may correlate with a five mile segment of moraine west and northwest of Newburgh. The New Hampton Moraine is also probably correlative with recessional positions between Otisville and Bloomingburg on the west.

Major esker systems are associated with both the Pellets Island and New Hampton Moraines, being slightly more dissected south of the New Hampton moraine. This suggests downwasting and stagnation associated with a 500 foot proglacial lake rather than recession of an active ice margin.

It is not possible to separate the Wallkill and Hudson lobes during the deposition of the closely associated Pellets Island and New Hampton moraines. These moraines have been tentatively correlated with moraines similarly banked against the Highlands east of the Hudson River in Dutchess County, New York. The eastern position noted by Gordon (1911) has been traced northeastward along the Highlands to Poughquag where correlation

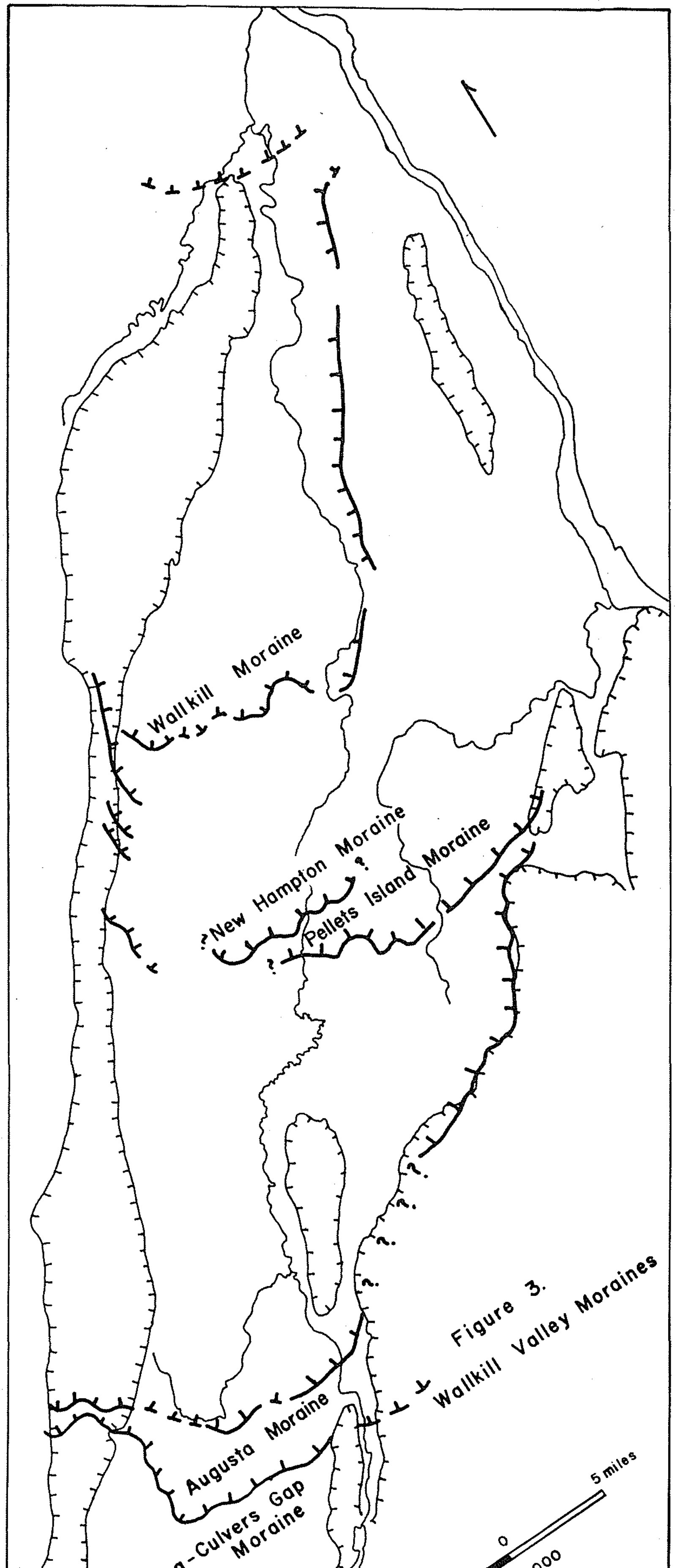

Figure 3. Wallkill Valley Moraines

with the massive kames at Wingdale in the Harlem Valley is inferred.

WALLKILL MORAINE

A fifth moraine is a complex of at least three ice marginal positions that are more or less continuously traceable across the Valley. This moraine is here named the Wallkill Moraine for the massive morainal topography east of the village of Wallkill (Stop G-2). Dissected remnants of outwash and stagnant ice deposits have been traced westward from the Wallkill River to Bloomingburg, at the base of the Shawangunks, using air photos#. The Wallkill Moraine is traceable northeastward for more than 20 miles until it banks against the northern end of the Marlboro Mountains.

The Wallkill Moraine appears to delineate the final recessional phase of the Wallkill Valley lobe. However, north of New Paltz the moraine loses its sharp definition and blends into an esker complex suggesting that stagnant Hudson Valley lobe ice was still present in the northeast. The innermost of the Wallkill Moraine ridges is here referred to informally as the State Prison Moraine. However, detailed mapping may show this to be an ice channel filling similar to those related to the Pellets Island and New Hampton Moraines.

The Wallkill Moraine is associated with a 400 foot lake stage. When the glacier retreated from the New Hampton position and the morainal dams were breached, drainage changed from southward to eastward via Otter Kill and Moodna Creek. At this stage waters from the Wallkill Valley must have joined an early phase of Lake Albany. East of the Hudson River this position may relate to the "New Hamburg Stage" of Woodworth (1905).

A sixth ice marginal position is inferred from drainage diversions and the probable position of ice dams (Stop G-4). This position may have been present in the vicinity of Stone Ridge in the Rondout Creek Valley and Rosendale in the Wallkill Valley. It is inferred from the presence of a 230 foot lake stage in the Wallkill Valley and one at perhaps 300 feet in Rondout Valley. This ice margin is presumed to be responsible for the diversion of the Wallkill River into a postglacial gorge (east of the ancestral gorge) between Tillson and its confluence with Rondout Creek. This position probably relates to some part of the sequence described by Cook (1942) in the Catskill quadrangle to the northeast.

PROGLACIAL LAKES

Lake sediments are present in many places along the banks of the Hudson River, however, with one exception, they are so closely related that only detailed mapping will serve to differentiate separate levels. In the Wallkill Valley, on the other hand, the high land to the south served as a natural barrier to drainage and extensive ponding resulted. As lower outlets were uncovered by northward recession of the ice front lake levels dropped, defining four distinct stages.

Salisbury (1902) described the initial stage of isolated ponds, well above 500 feet, referable to the Ogdensburg-Culvers Gap and Augusta Moraines.

Adams (1934) discussed stages at 500 and at 400 feet. The 500 foot level was determined by the divide between the Wallkill River drainage and the Delaware River drainage to the south. Cook (1924) believed this stage contained several small, local lakes but Adams correctly inferred it to be a large lake draining around remnants of stagnant ice.

The senior author acknowledges Grant-in-aid 26-62A from the New York State Research Foundation for the purchase of air photos for this study.

The 400 foot lake stage was initiated when the glacier had retreated north of the low point between the Hudson Highlands and Marlboro Mountains. Otter Kill and Moodna Creek drained this stage eastward to the Hudson River where a large hanging delta is presently borrowed extensively for sand and gravel. Other levels are present at about 320 feet and 220 feet, and perhaps at 180 feet. The 320 and 220 foot levels may define initial stages of Lake Albany or may represent a local sag in the Hudson Valley lobe, although no collapse structures have been noted as yet.

When the glacier retreated from the north end of the Marlboro Mountains the final lake stage commenced at 230 feet (Stop G-3). This stage drained northward into the Hudson trough via the lower Wallkill and Rondout gorges. The lake plain associated with this final stage is that which has frequently been interpreted as a floodplain in the lower Wallkill Valley.

Although the lake stages are all well-documented, formal names await detailed knowledge of the limits, dams, and history of each.

Lake Albany waters were probably present in the lower Wallkill Gorge after final recession of the ice front from the Wallkill Valley. The Lake Albany plain is present at 200 feet and perhaps again at 180 feet in the vicinity of Kingston. At Stop G-5 slumped Lake Albany clays are seen to overlie kame gravels. This suggests that stagnant ice was present in this vicinity during at least part of the development of Lake Albany as suggested by Cook (1942). Presumably the slumping is related to the later melting of the buried ice.

LATE-GLACIAL ENVIRONMENTS

In order to reconstruct the setting during glacial recession through the Wallkill Valley, a bog (New Hampton No. 1) in the lower Wallkill Valley was selected for study. The bog represented in this analysis is one of several (Middletown Quadrangle: 41°23'45" N, 74°23' W) which occupy kettle holes developed in the kame-esker-kettle terrain previously described three quarters of a mile southwest of New Hampton, New York, during the recession of the glacier from the Pellets Island and New Hampton moraines. This particular bog was chosen in preference to adjacent bogs after systematic probing revealed that it contained the longest sedimentary section (8.5m). In addition, the dry bog surface indicated that the lake-bog sequence had reached an advanced or climactic stage of development, with probable preservation in the peat of the pollen record of the floral communities which have successively occupied the bog site since deglaciation.

The sedimentary section was retrieved in 25 cm segments with a Davis-type piston corer#. The column consists of 2.5 meters of light and dark banded silts which were deposited directly over glacial drift (medium to coarse sand). Ninety-two light-dark sets were estimated and may represent varve-like deposition. The banded silts are overlain successively by approximately two meters of gray-brown clay-silt gyttja grading upward into dark brown silty peat, one meter of olive-colored silty peat, and three meters of brown peat up to the bog surface.

Samples for pollen analysis were selected from the 25 cm core segments and prepared by standard chemical processes. A pollen sum of 300 grains per slide was selected for the survey.

Analysis of the late-glacial pollen spectra contained in the core indicated the presence of pollen subzones which may be correlated with the pollen stratigraphy of southern New England and southern New York as summarized in Table 1. The basal pollen

The authors gratefully acknowledge the cooperation of M. Berkman, W. Conklin and J. Wolf for making this part of the operation possible.

ZONES			SOUTHERN WALLKILL VALLEY	SOUTHERN NEW ENGLAND	WESTERN LONG ISLAND
POSTGLACIAL	C3	(OAK)	Oak,Hemlock	Spruce rise Oak,Hemlock	Oak,Chestnut,Holly
	C2		Oak,Hickory	Oak,Hickory	Oak,Hickory
	C1		Oak,Hemlock	Oak,Hemlock	Oak,Hemlock
	B2	(PINE)	Pine,Oak	Pine,Oak	Pine,Oak
	B1		Pine	Pine	Pine
LATE-GLACIAL	A4	(SPRUCE)	Spruce returns	Spruce returns	Spruce returns
	A3		Pine,Spruce,Oak	Pine,Spruce,Oak	Pine,Spruce
	A1,2		Pine,Spruce	Birch,Spruce	Pine,Spruce
	T3	(HERB)	Pine,Spruce,Birch	Birch Park-Tundra	Pine,Spruce,Herb
	T2		Spruce,Pine,Fir Park	Spruce Park-Tundra	Spruce Park
	T1		Pine,Birch,Shrub	Tundra	Park-Tundra
	W		Glaciated	Glaciated	Park-Tundra Near-Tundra

TABLE 1: POLLEN STRATIGRAPHIC CORRELATIONS (after Deevey,1958; Sirkin,1957)

stratigraphy of southern New England and southern New York as summarized in Table 1. The basal pollen spectrums are similar to basal spectra found in southern New York (Sirkin, 1967) where pine and birch are dominant with spruce and willow, and the arboreal pollen (AP) represent 93 percent of the pollen. The nonarboreal pollen (NAP) are represented mainly by grass with Polygonaceae but not in proportions signifying a tundra vegetation.

The basal spectrum has been attributed to pollen, particularly pine and birch pollen, derived from distant sources (i.e., the unglaciated terrain in southern New York and New Jersey) since local vegetation and hence pollen production in the vicinity of the bog site would have been restricted by the presence of ice in the kettles. The presence of laminated or varve-like silts may indicate the proximity of glacial conditions or the presence of the 400 foot lake stage during the period of, or just prior to, the accumulation of these sediments. However, the presence of willow, alder, heath grass, and Polygonaceae attests to a local origin. This pollen assemblage is tentatively correlated with the Herb Pollen Zone, subzone T1 (Table 1) deposition which was initiated approximately 15,000 years B.P.

In the succeeding pollen spectra spruce and fir pollen increase while pine and birch decrease. The NAP rise to 14 percent of the pollen, mainly due to an increase in grass. A subsequent decline in spruce and an increase in birch completes a pattern of pollen representation which enhances the zonal resemblance to the T subzones of the Herb Pollen Zone in southern New England, but with a marked over-representation of pine and possibly an under-representation of NAP.

The tundra-like or spruce park tundra vegetation found on Long Island (Sirkin, 1967) and in Southern New England (Deevey, 1958) may therefore be represented here. One observation is that higher NAP percentages have been characteristically found at coastal sites, while inland sites have had very low NAP values (Cox, 1959; Whitehead and Bentley, 1963; Nicholas, personal communication). It also appears that due to the time transgressive nature of the pollen zones with glacial recession, the herb zone is diluted progressively northward and northwestward (inland) as the coniferous forests colonized regions to the south of the ice.

The implied presence of a spruce-fir park in this pollen spectrum may be evidence of a glacial stand or readvance in the Central Hudson region, and may be the equivalent of the T3 subzone of southern Connecticut (Leopold, 1956) which has been correlated with the Middletown advance in central Connecticut (Deevey, 1958).

The subzones of the Spruce Pollen Zone may be selected on the basis of (i) the pine-spruce-birch-oak-grass spectra (subzones A1-A2), which contain the late-glacial NAP maximum of 19 percent followed by (ii) an increase in the AP to 91 percent, mainly due to pine (subzone A3) and finally (iii) a spruce return (subzone A4) to over 10 percent of the pollen, along with birch, alders and pine. This spectra is indicative of the cold-moist preboreal climate, usually assigned to an ice advance in northern North America. Closer correlation of these zones with the established zonation in southern New England and southern New York has been made possible by a radiocarbon date of 12,100 years B.P.# from the base of the organic sections, which falls between the presumed A1-A2 and A3 subzones. These zones have been dated at 12,000 to 13,000 years B.P. according to radiocarbon chronology reported by Deevey (1958) for southern New England.

Overlying the Spruce Pollen Zone are well-defined Pine Pollen Zone spectra, initially pine (subzone B1) and, then pine, oak (subzone B2). Additional correlation of

This date, courtesy of Dr. David Thurber of Lamont Geological Observatory will be discussed in detail in a future publication.

this pollen record appears in oak-hemlock spectra (Oak Pollen Zone, subzone C1) in which pine diminishes progressively and NAP values increase to postglacial maximum of 28 percent of the pollen.

The upper surface of the bog may have been modified by commercial peat cutting as suggested by the oversteepening of the kettle slopes, deepening of the bog surface, and by the channel cut into the bog wall on the west or river side of the bog.

The bog shows no evidence of a higher water river stage during which a marl wedge was deposited against the river levee on the west side of the bog. Further radiocarbon age or pollen stratigraphic determination of the age of the marl is required to establish that episode within the framework of postglacial events.

GLACIAL RECESSION

Muller (1965) recognizes three Wisconsinan glaciations in western New York:

Valley Heads Substage
Kent Substage
Olean Substage

Muller considers the Valley Heads to be equivalent to the Port Huron Substage and the Kent equivalent to the classical Cary Substage of the midwest. The Olean Substage has been assigned both post-Farmdale (Denny, 1956) and pre-Farmdale (Connally, 1964) ages.

The pollen stratigraphy of New Hampton Bog No. 1 suggests that recession from the New Hampton Moraine took place prior to 15,000 years B. P. Thus, advance to the Ogdensburg-Culvers Gap position must have taken place in pre-Cary time, presumably during the classical Tazewell Substage of the midwest, and is pre-Kent in age. Until finer definition of the Olean Substage has been accomplished in western New York it is probably best to avoid this term in eastern New York.

If the recessional drift of the Wallkill Valley dates from a single glaciation as implied, and if the lake stages in the Valley are as closely associated with Lake Albany as implied, then Lake Albany must also date its origin from pre-Kent time. Although LaFleur (1965) has followed others in suggesting a Port Huron (Mankato) age for the Glens Falls readvance of Chadwick (1928) into Lake Albany, a Kent age must now be considered a distinct possibility.

SUMMARY

The Pleistocene history evident in the Wallkill Valley began with the advance, or readvance, of a Wisconsinan glacier to the position of the Ogdensburg-Culvers Gap Moraine. Directional indicators suggest that this glacier advanced in two lobes, one in the Hudson trough that spilled over into the eastern Wallkill Valley, and one in the central Wallkill Valley that split into sub-lobes at the Shawangunk Mountains.

As the glacier terminus retreated from the Ogdensburg-Culvers Gap position four lake stages were initiated. The first stage consisted of local ponds whereas the second stage consisted of a large lake at 500 feet, draining southward around remnants of stagnant ice into the Delaware River system. When the glacier retreated north of the Hudson Highlands a third stage came into existence at 400 feet draining eastward into the Hudson trough. The final stage began at 230 feet when the glacier retreated north of the Marlboro Mountains permitting northward escape of the lake waters via Rondout Creek.

With the retreat of the glacier terminus from the mouth of the Wallkill Valley, Lake Albany waters invaded at about 200 feet depositing sediment over stagnant ice remnants.

Pollen stratigraphy, confirmed by radiocarbon dating, indicates that recession from the Wallkill Valley began prior to 15,000 years B.P. This suggests that the Wallkill Valley drift, and probably Lake Albany, predates the Kent Substage of Muller (1965) and is correlative with the classical Tazewell Substage of the midwest.

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ROAD LOG FIELD TRIP A

Co-leaders: G. Gordon Connelly and Leslie A. Sirkin

TOTAL MILES	Miles from last stop	
00.0	00.0	Assembly point: Parking lot, Holiday Inn, Route 17M Newburgh, New York, near Thruway exit 17.
		Departure time: 8:00 a.m. All travel by bus!
		Leave Holiday Inn and turn left (east) on Route 17K.
0.2	0.2	Turn right (south) onto Union Avenue.
1.7	1.7	Turn left at the traffic light and proceed east on Route 207.
2.0	2.0	Bear right (south) on Temple Hill Road where sign says "To 32".
4.0	4.0	Railroad Crossing!
4.4	4.4	Turn right (west) at the traffic light at Vails Gate and proceed westward on Route 94.
5.1	5.1	Railroad Crossing!
7.2	7.2	Railroad Underpass. Schunemunk Mountain, a north-easterly plunging syncline is on the left. This is the easternmost manifestation of typical Appalachian, ridge-and-valley topography.
8.6	8.6	The village of Salisbury Mills with Moodna Creek close by on the left. Moodna Creek served as a major drainageway for proglacial lake waters in the Wallkill Valley and controlled the 400 foot lake level reported by Adams (1934).
10.8	10.8	Continue southwest on Route 94 through the village of Washingtonville. Washingtonville is the home of the Brotherhood Wineries, reputed to be the oldest in the country in continuing existence.
14.6	14.6	Railroad Underpass.
15.6	15.6	Note the post-glacial stream channel cut in bedrock. This channel is the result of a drainage reversal caused by the deposition of a crevasse filling (moraine?) south of Chester. This stream originally flowed southward into Black Meadow Creek but now drains only the muck area north of Chester.
16.4	16.4	The Chester Esker is on the right side of the road.
16.8	16.8	The road ascends the 60 foot high Chester Esker. This esker has its crest at about 540 feet and evidently represents a channel that drained southward through stagnant ice, into the 500 foot lake in the southern Wallkill Valley. This channel was probably in existence during the building of both the Pellets Island and New Hampton Moraines.

TOTAL MILES	Miles from last stop	
18.9	18.9	Turn right (south) on Academy Street (Route 94). Crevasse filling to left.
19.1	19.1	Turn right (west) onto Brookside Avenue (Routes 94 & 17M).
19.4	19.4	Turn left (south) on West Avenue (Route 94).
20.4	20.4	Turn left into road to Chester Ready-Mix.
20.9	20.9	STOP A-1. This gravel pit is operated by Chester Ready-Mix. It is part of a southward extension of the ice channel filling represented by the Chester Esker. Examine the relationship between ice-contact stratified drift, flow (?) till, and non-ice-contact drift. In addition, examine the exotic lithologies represented in the gravels.
		Return to Route 94.
21.5	0.6	Turn left (west) on Route 94. The road essentially parallels an ice-marginal position between here and Florida, New York.
24.8	3.9	At the center of the village of Florida continue straight across Route 17A onto Meadow Road. Be careful not to turn right or left into side roads or driveways.
25.6	4.8	Cross Quaker Creek on small bridge. This is the main muck farming area of Orange County. The organic soil is the result of filling of a 500 foot proglacial lake with lake silts and then organic deposits. On approaching the ridge of till knobs to the west a change in color of the topsoil illustrates the change from muck soil (developed from the bog deposits), to Canandaigua soils (developed from underlying lake silts and clays) to Cossayuna-Troy soils (developed from the till that underlies the lake deposits).
26.9	6.0	Turn left (south) on the Pulaski Highway following the series of drumlinized till ridges.
28.1	7.2	STOP A-2. Examine the lodgement till exposed in the cut behind the Big Island Garage. This till appears similar in lithology, weathering profile and soil development to the Olean till of western New York.
		Return north on the Pulaski Highway.
28.7	0.6	Note the distal face of the Pellets Island Moraine to the front and left.
30.4	2.3	Turn left (west) on Cross Road.
31.3	3.2	The proximal slope of the Pellets Island Moraine is to left.
31.6	3.5	Turn left (south) on Maple Avenue and stay to the right at the next fork.

TOTAL MILES	Miles from last point	
33.1	5.0	Bridge across the Wallkill River.
33.4	5.3	STOP A-3. This is the Pellets Island gravel pit of the Orange County Sand and Gravel Co. The undisturbed forset bedding on the distal side of the moraine suggests deposition into the open water of the 500 foot lake level. Exploratory cores for the City of New York Port Authority show almost 100 feet of lake clay, overlain by 0-20 feet of organic muck south of the moraine. Large blocks of flow (?) till are periodically exposed on the proximal side confirming it as an ice-contact face.
		Continue west on Maple Avenue.
33.7	0.3	Turn right (north) on unamed road. The New Hampton Moraine can be seen on the right, north of the Pellets Island Moraine.
35.4	2.0	Turn right (east) on old Route 17 at the blinker light.
35.8	2.4	Turn right (east) onto Route 17M. The proximal slope of the New Hampton Moraine can be seen on the right.
36.3	2.9	Bridge across the Wallkill River.
37.0	3.6	Turn left (north) on Hartly Road. Continue over the hill and stop just north of the low stone wall that divides two fields.
37.3	3.9	STOP A-4. Leave the buses and cross the road to the west. Walk up the gentle slope parallel to the stonewall until the trail becomes clear in the orchard. Follow the trail for about 1/4 mile before descending into the Berkman bog. The implications of the pollen record will be discussed in relationship with the deglaciation of the region and the drainage history of the bog.
		Return to the buses. Continue north on Hartly Road.
37.8	0.5	Railroad Crossing!
38.0	0.7	Turn right (north) on Cheechunk Road at Stop Sign.
38.2	0.9	Turn left (north) on Owens Road. There are several blind curves on this road as we approach Route 17. Use of a horn is advisable.
39.9	2.6	STOP A-5. Leave the buses and gather on the hill on the right side of the road. Observe the Phillipsburgh crevasse filling that trends to the northwest toward the Wallkill River. QUESTION: Why are there no drainage features nor ice-contact deposits to the south and east of this feature?
		Continue northwest parallel to the crevasse filling on the left and Route 17 on the right.
40.4	0.5	Turn right toward Route 17 at the Stop Sign. Then proceed north across Route 17 being very careful of high speed traffic.

TOTAL MILES	Miles from last point	
41.5	1.6	Bear right on Hill Road at the fork.
42.7	2.8	Continue north across Scotchtown Road.
42.8	2.9	Turn right (east) on Everett Road.
44.2	4.3	Turn left (north) on Route 207.
46.6	6.7	Railroad Underpass, 11'6" clearance.
46.7	6.8	Bear left on Route 416 at the fork.
48.1	8.2	Turn left into the Orange County Picnic Grove.
48.3	8.4	LUNCH STOP.
		Return to Route 416.
48.5	0.2	Turn right (south) on Route 416.
52.4	4.1	Turn right (west) on Everett Road.
53.7	5.4	Turn left on Hill Road.
53.8	5.5	Turn right (west) on Scotchtown Road.
54.7	6.4	Bridge across the Wallkill River. The river flows on bedrock on the east bank.
55.1	6.8	STOP A-6. This is one of the gravel pits operated by E. Tetz & Sons. Examine the pebble lithology as contrasted with that seen at Stop A-1. QUESTION: What is the significance of the large boulders of Shawangunk conglomerate?
		Continue northwest on Scotchtown Road.
55.3	0.2	Turn right (east) on Stoney Ford Road.
56.1	1.0	Turn left into dirt road and stop in the trees at the first flat area.
56.3	1.2	STOP A-7. Cross through the barbed wire fence on the left side of the road and proceed up the hill to the large kettle hole. Here the significance of the stagnant ice topography found in the Wallkill Valley will be discussed.
		Return to the main road.
56.5	0.2	Turn left (east) on Stoney Ford Road. The road traverses a plain of washed till adjacent to the Wallkill River.
57.6	1.3	Turn left (north) at the Stop Sign and drive through more kame complexes similar to stops A-6 and A-7.
58.6	2.3	Bear right at the Railroad Underpass, 10'6" clearance.
59.2	2.9	Turn left (west) on Route 211. The kame complexes are well displayed on the left for the next two miles.
61.6	5.3	Turn right (north) on Scotchtown Road.
62.8	6.5	Continue straight through Scotchtown at the Stop Sign.

TOTAL MILES	Miles from last point	
65.1	8.8	Ascend the distal slope of the Circleville Moraine. The relationship of this moraine to the Pellets Island and New Hampton Moraines is uncertain.
65.7	9.4	Turn left and then right onto the Goshen Turnpike at Circleville. The right turn follows the left turn by only about 100 feet.
65.9	9.6	Railroad Crossing!
68.3	12.0	Turn left (south) onto the dirt road and stay left at the driveway.
68.5	12.2	STOP A-8. This is one of a number of gravel pits operated by the Dickenson Sand and Gravel Co. of Bloomingburg. Examine the drift lithology. The significance of the numerous crevasse fillings in the Shawangunk Kill Valley north of Otisville will be discussed.
		Continue southwest on the dirt road.
68.8	0.3	Pass under Route 17.
69.2	0.7	Turn right (west) on Shawangunk Road.
69.3	0.8	Turn left (south) on Route 17M.
70.6	2.1	Turn left onto Route 17 EAST. This is the second left turn onto Route 17, the first of which goes west. If any unusual or significant openings due to road work are encountered an appropriate stop will be made.
84.6	16.1	The Chester crevasse filling and Chester Moraine are seen on the left. Camp La Guardia is located on the Chester Moraine.
93.9	25.4	New York State Thruway to Albany and Buffalo.
98.4	29.9	Note the mass wasting evident in the till cut to the right.
99.6	31.1	Note the massive valley-choker moraine to the right. This pit once displayed magnificent forest bedding toward the south.
109.5	40.0	Turn right at NYS Thruway EXIT 17 to Newburgh.
110.2	40.7	Stay left to Route 17K.
110.4	40.9	Bear right toward Route 17K (Middletown).
110.6	41.1	Join Route 17K proceeding west.
110.7	41.2	Continue straight at the traffic light.
110.9	41.4	Arrive at the Holiday Inn, Newburgh, New York.

THE ECONOMIC GEOLOGY OF THE MID—HUDSON VALLEY REGION

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Vassar College

SIMON SCHAFFEL
The City College of New York

Introduction

A diverse terrain endowed with a wide variety of available mineral resources, sustained demand for these resources and economical means of transportation have combined to foster a dynamic mineral industry in the Mid-Hudson Valley region which has prospered since the early 19th century. Production valued at about 100 million dollars in 1965 accounted for approximately one-third of the State's entire mineral economy. Of greater significance is the fact that the Mid-Hudson Valley's mineral production is concentrated in less than one percent of New York State's total land area (47,944 square miles). The principal products are crushed stone aggregate, building stone, lightweight aggregate, sand and gravel, portland cement, natural cement and brick — materials all necessary to building and highway construction.

Systematic geologic studies of the nature and use of rock raw materials have produced revolutionary changes in the economics of industrial mineral production in the Hudson Valley during the last decade. The result has been an increase of crushed stone reserves by a factor of 3 to 5, cement reserves by a factor of 5 to 10 and lightweight aggregate reserves from nothing to well over a billion tons. This represents another example of taking what is available and utilizing it all, by separation or by blending, for the most useful purpose. The economic rock section ranges in age from Cambrian to Middle Devonian (Tables B1 and B2).

Trip B is specifically planned to allow participants the opportunity to examine in a day's time the greatest variety of rock raw materials and mineral commodities typical of the Mid-Hudson Valley. The following U.S. Geological Survey 7.5-minute topographic quadrangles cover the route of the trip in order: Newburgh, Wappingers Falls, Poughkeepsie, Hyde Park, Kingston East, Kingston West, Rosendale and Clintondale.

The only publication dealing in depth with the economic geology of the Hudson Valley region and available on request from the Hudson River Valley Commission is as follows:

Broughton, John G., Davis, James, F., Johnson, John H., The Hudson: Mineral Resources: p. v, 103, 3 Pl., 12 Figs.; A report on the geology and mineral resources of the middle and lower Hudson Valley; State of New York, Hudson River Valley Commission, Oct., 1966.

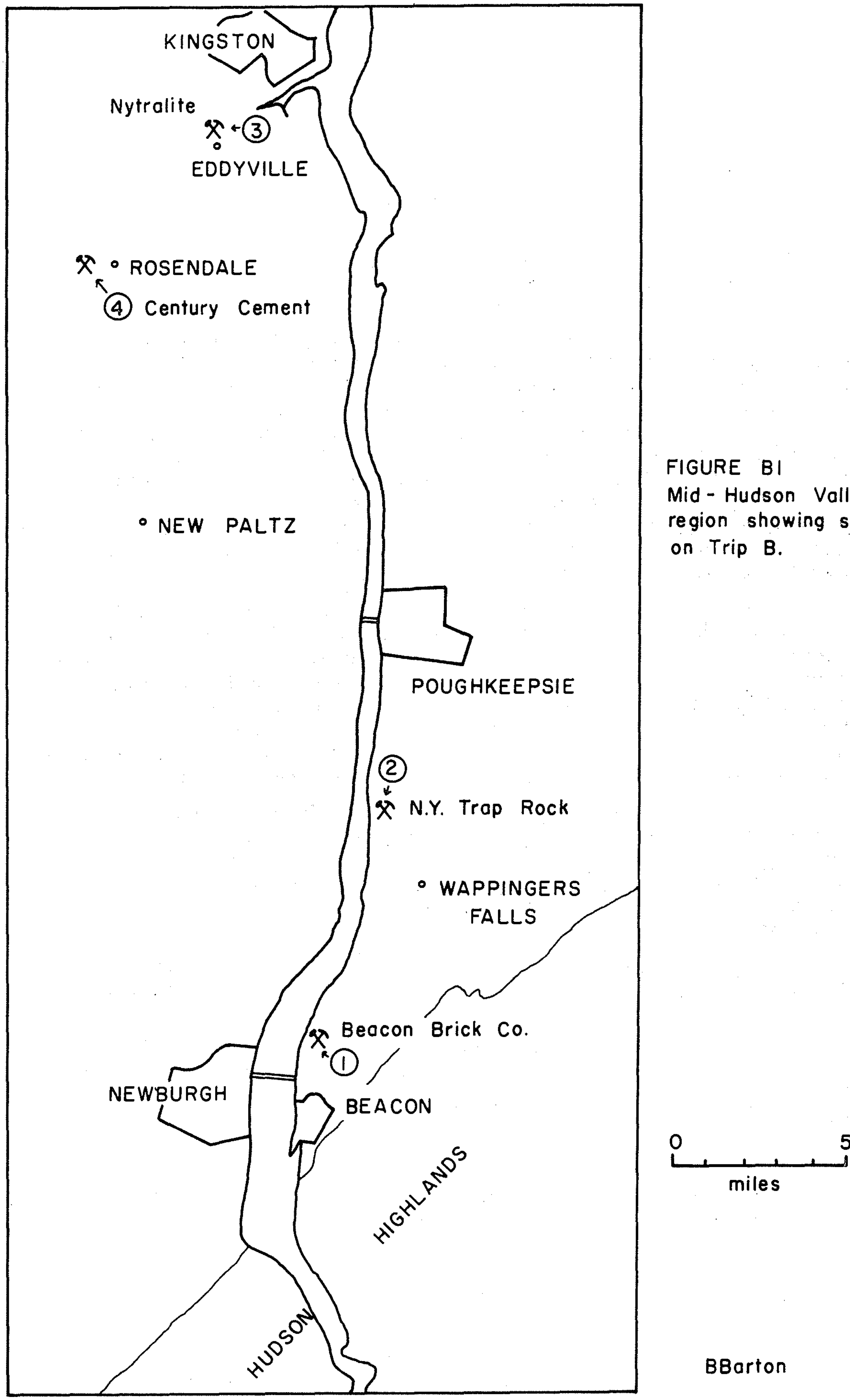


FIGURE B1
Mid - Hudson Valley region showing stops on Trip B.

BBarton

ROAD LOG TRIP B

Co-Leaders: John H. Johnsen and Simon Schaffel

Cumulative Mileage	Distance between points	
		Time: 8:30 A.M.
0.0		Leave Holiday Inn and turn east (left) on Route 17K. Precambrian Highlands of the Hudson ahead and to south (right).
0.3	0.3	Turn north (left) for Interstate 84 at traffic light.
0.8	0.5	Entrance to Interstate 84. Turn east (right).
1.0	0.2	Road cut in Upper Normanskill shales (brachiopod facies) of Ordovician (Trenton) age.
2.8	1.8	Road cut in fault block of Cambrian-Ordovician dolostones of the Stockbridge Group.
3.7	0.9	Proceed east across the Newburgh-Beacon Bridge. Note the Hudson Highlands on right (southeast to south). The two principal ridges reaching to the river's edge (Breakneck Ridge on the east and Storm King Mountain on the west) mark the northwestern front of the Precambrian crystalline Hudson Highlands. The northeast-southwest boundary with the Paleozoics of the Great Valley is marked by a moderately high angle reverse fault dipping toward the southeast. The Storm King Formation (hornblende granite, hornblende granitic gneiss and leucogranite) is the most resistant of the Highlands lithologic units and forms the two ridges. The Hudson River forms a gap separating these ridges which is commonly referred to as the "Northern Gateway to the Hudson Gorge or Hudson Highlands". In the more than 150 miles between Green Island Dam at Troy and New York Harbor, the Hudson River is an arm of the sea for it experiences the daily rise and fall of the oceanic tides. Traces of salt are detectable in the estuary north nearly to Poughkeepsie, but normal marine salinity extends only to the Northern Gateway. The Catskill Aqueduct of the New York City Water Supply system passes from Storm King Mountain across the river into Breakneck Ridge (Figure B2). The pressure tunnel through solid rock more than 1,000 feet below the Hudson is one of the classic engineering geologic projects of all time. Construction of a pumped-power generating plant using a storage basin on top of Storm King Mountain has been proposed by the Consolidated Edison Company of New York; this project has been the subject of substantial publicity recently. The Beacon Brick Corporation (Stop 1) can be seen one mile north (left) on the east bank at Brockway.
5.2	1.5	Toll booth.

Cumulative Mileage	Distance between points	
5.5	0.3	Exit Interstate 84 on right, proceed up slight grade and turn north (left) on Route 9D towards Wappingers Falls.
6.3	0.8	Turn west (left) on Brockway Road opposite Gulf gasoline station. Sign indicates entrance to Denning Point Brick Works (now Beacon Brick Corporation).
6.8	0.5	Turn north (right) on unimproved road to shale quarry.
7.0	0.2	Time: 8:55 A.M. STOP 1 (45 minutes):

STOP 1: Shale quarry and clay pit of the Beacon Brick Corporation

Exposed in the quarry are grayish-black, red and green slaty shales of the Normanskill Formation (Table B1) which are blended with clay to manufacture brick. Note slaty cleavage parallel to bedding.

Hudson Valley brick is produced by either the "soft mud" or "stiff mud" process. "Soft mud" brick is made from clay to which an excess of water has been added to secure plasticity. The soft mud is placed in wooden molds which have been dusted with sand and the clay is allowed to dry before firing. Extreme care must be exercised to avoid drying cracks and shrinkage. The "stiff mud" process is used most frequently by the modern brick industry. Highly plastic clays are undesirable for this process so that ground shale is usually added to the mix. The stiffer clay or clay-shale mix is extruded through a rectangular die and bricks are cut off by taut wires. These unfired bricks, being stiffer, can be handled with less danger of deformation.

Proceed to clay pit. Exposed in the pit is clay that represents fine mud deposited in one of many meltwater lakes that occupied the Hudson Valley during the retreat of the ice in the Late Pleistocene. The clay is normally bluish gray but it may be yellow when weathered due to the oxidation or iron. Thin beds and lenses of sand are frequently interstratified with the clay. The thickness of the clay is variable in this region, but it may exceed 200 feet in some localities. This glacial clay is well adapted to brick manufacture. It is plastic and usually has sufficiently large proportions of fluxing agents - such as alkalies, iron, lime and magnesia - to permit vitrification at relatively low temperatures. The finished product is generally red or pink in color.

The Beacon Brick Corporation uses a clay-shale mix to make extruded wire-cut brick. Firing takes place in a tunnel kiln having a capacity of 100,000 bricks per day. The chief market area is New York City with transportation by barge.

Lightweight aggregate is manufactured from shale or clay by heating these materials until they expand to form porous, scoriaceous material by the evolution of gas bubbles at elevated temperatures (see Stop 3). The Normanskill Shale is considered a potential source of lightweight aggregate raw material; however, pilot tests of the shale from this area yielded an unsatisfactory product because of the lack of compositional uniformity and the large amount of micro- and mega-structural diversity. The slaty cleavage caused slivery rather than equidimensional fragments on crushing which produced a pleated appearance on bloating similar to expanded vermiculite. Although this structure does not necessarily result in an aggregate of low strength, it does make a less attractive aggregate in terms of con-

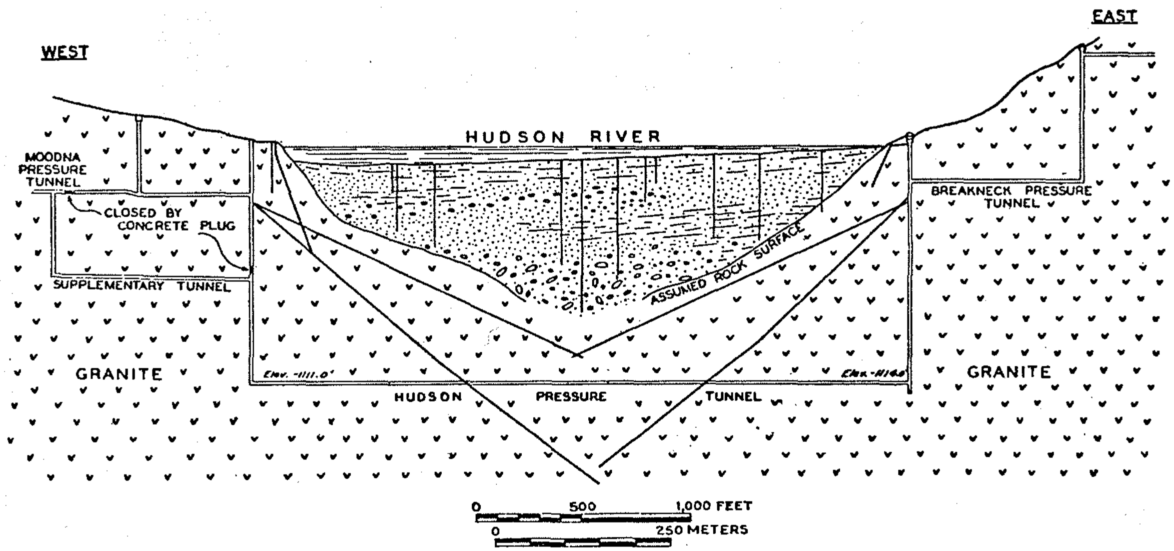


Figure B2. Geologic section across the Hudson River at Storm King, based on exploratory borings for the Catskill Aqueduct. From XVI International Geological Congress, Guidebook 9, p. 108, 1933.

sumer acceptance.

So far as is known, there has been no attempt to produce lightweight aggregate from Hudson Valley clay.

Cumulative Mileage	Distance between points	
		Time 9:40 A.M.
7.0		Leave shale quarry and retrace route via Brockway Road to Route 9D.
7.8	0.8	Turn north (left) on Route 9D.
12.0	4.2	Hughsonville.
12.8	0.8	Entering Wappingers Falls.
13.3	0.5	Leave Route 9D by turning east (right) on East Main Street at traffic light.
13.6	0.3	Follow directions to Poughkeepsie by bearing left (north) on Route 9 at traffic light.
14.4	0.8	Crossing Wappingers Lake.
15.0	0.6	Traffic light at intersection of Routes 9 and 9D. Continue north on Route 9 to next traffic light.
15.8	0.8	Turn west (left) at traffic light onto Old Post Road (opposite Texaco and Gulf gasoline stations).
16.0	0.2	Turn south (left) on Sheafe Road at bottom of hill. For the next half mile glacio-fluvial sands and gravels exhibiting ice contact features are visible on right.
16.7	0.7	Bear right on road leading down to the New York Trap Rock Corporation - Clinton Point Plant.
17.7	1.0	Cross bridge over N.Y. Central Railroad and follow signs to Plant Office.
17.9	0.2	Storage silos capped by screen house on left. The crushed stone is separated here into sizes ranging from 2.5 inches to stone screenings (material passing a 1/4-inch screen).
		Time: 10:10 A.M.
18.0	0.1	STOP 2: (One hour):

STOP 2: New York Trap Rock Corporation, Clinton Point Quarry

Plant Office and loading dock. Hard hats will be loaned to those participants not bringing them. The borrowed hats will be returned at Nytralite Aggregates, Inc. (Stop 3).

Two belts of dolostone suitable for crushed stone aggregate occur along the Hudson River in the lower reach of the Mid-Hudson Valley (see Lower Hudson Sheet, Geologic Map of New York State, 1961). The southernmost of these two belts follows the northern margin of the Hudson Highlands north-northeast from the vicinity of Beacon to the eastern portion of Dutchess County where it veers more northerly, eventually crossing into northern Connecticut and Massachusetts; the other belt begins southwest of Newburgh and also trends north by northeast to cross the Hudson at New Hamburg (situated at the mouth of Wappinger Creek) where it occurs in two distinct bands over a short distance and continues in the same north-northeasterly direction to the upper part of Dutchess County.

The rocks take their name, Stockbridge Group, from Stockbridge, Massachusetts, where the northeastern extension of the southernmost belt has been metamorphosed to marble. In the field trip area, the carbonates are unaffected by metamorphism and frequently are referred to as the Wappinger Group, a name well established in the literature. The Stockbridge succession includes carbonate rocks that are Late Cambrian to Early Ordovician in age although that part of the succession in the vicinity of the Hudson River may be all Cambrian. The sequence includes a series of dense to finely crystalline, gray dolomitic rocks ranging from dolomitic limestone to dolostone which collectively are calcitic dolostones.

At Clinton Point, the rock is dolostone, with a magnesium carbonate content of 38.16 percent. Here the New York Trap Rock Corporation, a subsidiary of the Lone Star Cement Corporation, produces every conceiveable size of stone ranging from riprap to stone sand and screenings.

The quarry opening is effectively blocked from river view by a 500-foot wide buffer zone or "mercy strip". The dolostone reportedly extends to considerable depth and a portion of the quarry floor is now 60 feet below the level of the Hudson River. Downward development is possible because the rock in the buffer zone is sufficiently tight to hold back the river water.

Two inactive quarries are located in a different part of the dolostone sequence on the west bank of the Hudson opposite New Hamburg at Cedar Cliff. In these quarries the dolostone is locally characterized by considerable chert of a variety that is known to have a deleterious effect when used as concrete aggregate. If reopened, selective quarrying would be necessary until new advances in concrete technology nullify these effects. There is no reason why other applications are not possible, provided the rock meets the necessary specifications.

Retrace route past screen house and storage silos.

Cumulative Mileage	Distance between points	
18.3	0.3	Overhead conveyer belt. Note dolostone on left dipping gently southwestward.
18.4	0.1	Cross bridge over N.Y. Central Railroad and turn north (left) into quarry.
18.6	0.2	Lowest operating level on right; 42-inch gyratory primary crusher on left.
19.0	0.4	Continue north by bearing slightly left on road through riprap storage area.
19.1	0.1	Stop to examine and sample dolostone.
19.2	0.1	Northwest quarry wall on left. Note steepening of dip near northwest border of dolostone fault block, minor normal faulting (one layer displaced about one foot), and close block jointing. Normal gentle dip is shown on north wall of quarry.

Cumulative Mileage	Distance between points	
19.4	0.2	Remnant of glaciofluvial fill on irregularly eroded bedrock containing buried stream channels and sink holes. View area on foot. Drill core data gives evidence that uniform gentle dip in main quarry area changes into broad gentle folds to north. Present north face shows steepening of dip.
		Retrace route to crusher area.
20.0	0.6	Primary crusher on right. View crushing operation if time permits.
		Time: 11:10 A.M.
20.3	0.3	Leave N.Y. Trap Rock. Turn left at east end of bridge over railroad.
21.3	1.0	Turn north (left) on Sheafe Road at end of quarry road.
22.0	0.7	Turn east (right) on Old Post Road and proceed uphill.
22.2	0.2	Turn north (left) on Route 9 (Albany Post Road) at traffic light.
24.1	1.9	Note Marlboro Hills on left across Hudson River beyond IBM plant. These hills are composed of tough, resistant graywackes and fine sandstones of the Austin Glen Member, Normanskill Formation.
26.0	1.9	Entering City of Poughkeepsie.
26.8	0.8	View of Hudson River and Mid-Hudson Bridge.
27.6	0.8	Exit left for Mid-Hudson Bridge.
27.9	0.3	Toll Gates.
28.5	0.6	West end of Mid-Hudson Bridge. Note excellent exposures of Normanskill Formation (Austin Glen Member) showing massive graywackes with interbedded slaty shale.
29.1	0.6	More excellent exposures of the Austin Glen Member.
29.5	0.4	Highland Traffic Circle. Turn north (right) to Kingston via Route 9W.
33.3	3.8	End of divided highway.
33.6	0.3	Good view of Hudson River on right with Eymard Seminary on bluff across river.
43.2	9.6	Rondout Creek Bridge (tidewater inlet). Cross bridge and continue straight uphill on Route 9W.
43.8	0.6	Turn right at "T" intersection, remaining on Route 9W.
44.2	0.4	Traffic light. Leave Route 9W by continuing straight ahead on Route 28 (Broadway).
		Time: 12:00 Noon
44.6	0.4	#REST STOP (15 minutes)

#REST STOP: Trailways Bus Terminal

Corners of Broadway and Pine Grove Street, Kingston. Lunch is planned for STOP 3 where ample time will be available because a short tour of the facilities can be accomplished only in small groups. It is possible that some participants may not be able to wait until 1:00 or 1:30 P.M. Those who wish to obtain a quick snack or a candy bar may do so here.

Time: 12:15 P.M.

Cumulative Mileage	Distance between points	
44.6		Leave Trailways Bus Terminal and continue west on Broadway. Turn left at the second traffic light past the New York Central Railroad underpass onto Route 32 (Henry Street).
44.9	0.3	Turn left on Henry Street (Route 32).
45.4	0.5	Turn left on Fair Street (one-way), Route 32.
45.5	0.1	Continue on Route 32 at intersection by bearing half right on Boulevard.
46.1	0.6	Gentle anticlinal fold in Schoharie Formation on left.
47.3	1.2	Traffic light for Nytralite truck crossing. Turn right into quarry.
		Time: 12:30 P.M.
47.5	0.2	STOP 3 (Two hours)

STOP 3: Nytralite Aggregate, Inc. - Quarry and Tour of Plant

Nytralite Aggregates, Inc. is one of the leading producers of lightweight aggregate in the Mid-Hudson Valley. Lightweight aggregates are special materials incorporated with cement in the manufacture of concretes which range in weight from 120 pounds per cubic foot to less than 62 pounds per cubic foot. The latter is able to float on water. By comparison, conventional concretes containing other aggregates, such as crushed carbonate rock seen at Stop 2, weigh about 150 pounds per cubic foot.

Lightweight aggregate is used in substantially more than half of the concrete block produced in the United States. The desirable properties gained by this usage are: lightness, high strength-to-weight ratio, low shrinkage, low thermal conductivity, good acoustical properties, a coefficient of expansion similar to that of steel and low production costs. The use of lightweight aggregate in the concrete roadway of San Francisco-Oakland Bay Bridge reduced the cost of steel by three million dollars.

Lightweight aggregate may be manufactured from clay or shale by heating these substances until they expand to form porous, cinder-like materials. Expansion is a bloating process in which two conditions occur simultaneously. Upon firing, the clay or shale fuses to form a viscous liquid, while at the same time, a gas, released as a result of mineral decomposition, becomes entrapped within the viscous mass. If the gas-producing mineral, or minerals, decomposes before any appreciable liquid formation takes place, expansion will not occur, as the gas will escape through the open-pore structure. Satisfactory expansion also will not occur if the gas is evolved at temperatures much greater than the softening point, as the gas will again be lost because the melt will be too fluid to retain it. If, for some reason, the gas is retained under this condition, cells may be too large and their walls too thin for good strength.

Non-bloating argillaceous materials can often be induced to expand by adding pulverized coal and pelletizing into desired size prior to ignition.

The rock most suitable for the manufacture of lightweight aggregate is a massive, somewhat silty (arenaceous), unweathered shale of uniform quality. It may contain a small amount of calcite, either disseminated or as thin veinlets, and a little pyrite. Slaty cleavage should not be well developed, but it causes no problem in its incipient stages. This type of rock yields a good, uniform aggregate of adequate strength and an acceptable appearance. It bloats at approximately 2000 degrees F. The Esopus Shale exposed in the Nytralite quarry fits this description. Note the gentle dip of the massive beds to the southeast (north face) and nearly vertical cleavage (east face). The quarry is located on the gently-dipping western limb of an asymmetrical syncline, the axial planes of which dips to the southeast. The trace of the axial plane is roughly parallel to the crest of Fly Mountain. Fly Mountain is basically a northeast-trending asymmetric synclinal ridge characterized by a number of similarly-trending subsidiary folds. It is composed mainly of Late Silurian and Early Devonian carbonate rocks (Figures B3, B4) which have been thrust northwestward over the Esopus Shale along multiple faults. Exit quarry.

Cumulative Mileage	Distance between points	
47.6	0.1	Cross Route 32 and proceed up road to plant.
47.8	0.2	Exit buses and proceed on foot. Note initial test quarry in Esopus Shale to north. Walk up hill, noting the carbonate rocks, to primary crusher and Plant Office. Route essentially parallels the section given in Figure B4.
48.2	0.4	Plant Office. Lunch stop and tour of plant. Refer to flow diagram (Figure B5).
		Time: 2:30 P.M.
48.2		Leave Nytralite Aggregates, Inc. Board buses, returning to Route 32.
48.7	0.5	Turn south (left) at traffic light on Route 32. The Esopus Shale crops out along the north (right) side of the road for the next half a mile.
49.2	0.5	The Esopus Shale is exposed on both sides of Route 32.
50.0	0.8	End of Esopus outcrop. For the next 1.3 miles, various Lower Devonian formations are exposed in road cuts but the rapid changes in lithology do not permit recognition from the bus window.
51.3	1.3	N.Y. State Thruway (officially the Gov. Thomas E. Dewey Thruway).
52.9	1.6	Rosendale Shopping Center on right.
53.0	0.1	Turn southwest (right) on Route 213 through the village of Rosendale.
53.7	0.7	Abandoned natural cement mines on right.

Cumulative Mileage	Distance between points	
53.8	0.1	Pass under railroad trestle.
53.9	0.1	Sharp right turn uphill to north on Binnewater Road.
54.2	0.2	Vertical continuous draw type kilns used by the Century Cement Co. in the manufacture of natural cement of left. These kilns, built in batteries, are about 40 feet high, 10 feet in diameter and lined with refractory brick. The charge is made up of alternate layers of crushed natural cement rock and anthracite coal. It is loaded from the top of the kiln and consists of three 2.5-foot layers, consisting of 7-inch, 2 to 4-inch and 2-inch fragments, in that order. The crushed natural cement rock layers are separated from one another by approximately 3 inches of pea-sized anthracite coal (equal to 10 percent of the natural cement raw material) and the procedure is repeated. Burning takes four days. Loading is done so that one-fourth of the calcined rock is withdrawn each day and a proportionate new charge of raw stone and fuel to refill the kiln is added to the top. From the kiln, portable pan conveyers are used to transport the burnt material to trucks for delivery to the mill. At the pan conveyor the material is hand picked, so that any under- or over-burned clinker is discarded. At the mill, the clinkers are put through a series of crushing, pulverizing and finish grinding and then conveyed to silos to await shipment.
54.8	0.6	Turn left at Keator's Corner on Sawdust Ave.
55.2	0.4	Turn left into truck entrance for the Century Cement Mfg. Co., staying on hard surface road (right).
55.6	0.4	Century Cement Mfg. Co., Inc. mill. This mill is unique in that it uses the only vertical cement kiln in this country. The raw mix - largely a controlled blend of Becraft Limestone (from quarry across road on right) and Mt. Marion Shale (imported)— is pulverized, combined with powdered coal and pelletized before firing. Masonry and portland cements are produced.
55.7	0.1	Plant Office. Proceed straight ahead to underground operation.
55.8	0.1	View of Shawangunk Mountain and the fire tower at Lake Mohonk. Shawangunk Mountain is capped by very resistant quartzite and quartz pebble conglomerate of the Shawangunk Formation which lie with distinct angular unconformity on the intricately folded Normanskill (Martinsburg) shales.
		Time: 3:00 P.M.
56.0	0.2	STOP 4: (One hour)

STOP 4: Natural Cement Mine, Century Cement Mfg. Co.

Natural cement is produced by calcining an impure, argillaceous limestone or dolomitic limestone containing from 15 to 40 percent silica, alumina, and iron oxide at a comparatively low temperature (about 1400° F.) so that decarbonation but no fusion takes place. The burned mass will not slake if water is added, but when ground to a powder it will harden rapidly with the addition of water. Natural cement acquires most of its untimate strength in 5 years and only one-eighth of its ultimate strength in 7 days whereas most portland cements approach their ultimate strength in one year and reach 65 to 75 percent of their ultimate strength in 7 days.

In the United States, the cement industry began in 1818 with the discovery of natural cement rock near Chittenango, New York, by Canvass White. White applied to the State of New York for exlcusive rights to manufacture the cement for 20 years. His request was denied but the State awarded him $20,000 in recognition of his valuable discovery. The cement was used in the construction of the Erie Canal.

In 1825, during the building of the Delaware and Hudson Canal, a natural cement rock was discovered here at Rosendale. Work was progressing along the route of the canal through the farm of Jacob L. Snyder when it became necessary to blast through some rock. The rock, as blasted, had the appearance of limestone and fragments were taken to a blacksmith shop at High Falls to produce lime. The stone was burned in the forge and attempts to slake it were made by adding water. The calcined material, soft and chalky after burning, did not slake but instead, after a few hours, lost all of its chalkiness and began to harden. It had been planned to obtain the cement necessary for the canal locks from Chittenango but with the discovery of cement along the route, a contract was awarded to a Mr. John Littlejohn to supply the canal's needs. Littlejohn built a "pot" kiln in which the burning of each charge was a separate operation. The pot kiln was a shaft excavated in the side of a hill and lined with cement rock. At the base of the kiln, an "eye" or shaft at a right angle to the main shaft was filled with cordwood and an arch of large cement rocks, to act like a grate, was formed just above the cordwood. The kiln was then filled with cordwood and an arch of large cement rocks, to act like a grate, was formed just above the cordwood. The kiln was then filled with broken cement rock and the cordwood ignited. The burning continued until the highest stone in the kiln was calcined (5 to 6 days) and then the entire charge was withdrawn. The kiln was then recharged and the procedure repeated.

The charge, as drawn, contained some raw and some over-burned materials. These were carefully removed and the raw material was used in the next kiln charge while the over-burned material was discarded. This procedure was necessary not only from a technical standpoint but also from a mechanical one. The mill equipment would grind neither the hard over-burned clinker nor the hard under-burned stone. The grinding equipment was fashioned on the same principle as a grist mill, utilizing millstones made from the quartz pebble conglomerate or "grit" of the Shawangunk Formation. The growth of the natural cement industry fostered a sizeable millstone business.

The rocks in the Rosendale district are so intricately folded and faulted that natural cement raw materials crop out almost everywhere. Repeated exposures are clearly indicated by the many abandoned mines in the region and it is obvious that the early miners knew what to look for. The natural cement rock was at first quarried but eventually it became necessary to drive headings and open a mine where the dip carried the desired rock below the surface. To aid visibility, it was customary to mine down dip a certain distance, return to the outside, and create a similar new opening 30 feet or so along the strike. These headings would then be worked at right angles until they were connected. The procedure was repeated again and again, leaving a series of adits, which provided the light to work with, separated by 30-foot pillars. As it became necessary to penetrate deeper underground, illumination was provided by kerosene torches and the miners copied from their successful adits the scheme of leaving 30-foot pillars to support the roof. This room and pillar arrangement is clearly demonstrated in the Century Cement mine.

Natural cement production in the United States grew from 100,000 bbls. a year in the 1830's to 10,000,000 bbls. per year in 1899. At the peak of the industry, in the Rosendale district, some 20 plants employed 5,000 men and turned out 4,000,000 bbls. per year.

About 1894, portland cement, a carefully controlled blend of cement raw materials to insure uniformity, came into general use. In 1900 production of natural cement and portland cement was identical, 8,500,000 barrels each. During the early 1900's, the first large structure of its type to be entirely constructed with portland cement was the Boonton Dam in New Jersey. The Boonton Dam was to be a part of the water supply of Jersey City and Rosendale natural cement was originally specified for its construction. However, a director of the Alpha Portland Cement Company was a member of the Board of Water Supply and he proposed to supply the Jersey City job with portland cement from his company at the same cost as Rosendale natural cement. The dam was built with portland cement. Then portland cement gained ascendency over natural cement and by 1910 natural cement production throughout the United States was reduced to about 1,000,000 bbls. The plants began to close down after the start of the 20th century and by 1920 only one plant remained in the Rosendale district - Century Cement. In fact, this company is the only producer of natural cement in the United States today and that on a limited basis.

The natural cement produced in the Rosendale district is a low lime, high silica, high magnesia, hydraulic cement of pozzolanic properties. A typical chemical analysis of the raw cement rock (Rosendale Member of the Rondout Formation) mined by Century Cement is:

SiO_2	17.5
Al_2O_3	5.0
Fe_2O_3	2.8
$CaCO_3$	41.5
$MgCO_3$	31.5
Alkalies	1.7
Total	100.0%

The working faces are now about half a mile from the mine entrance and slightly more than 100 feet below the surface. Production is presently limited to the Rosendale Member.

A significant portion of the mined-out lower level has been leased for the underground storage of vital records. Construction of vaults and other preparations are in progress.

MINE SECTION
CENTURY CEMENT MFG. CO.

Manlius Formation

——— roof, upper level; 2' below Manlius Fm.

Rondout Formation:

Whiteport Member 14'

——— floor, upper level

Glasco Member 14'

——— roof, lower level

Rosendale Member 22'

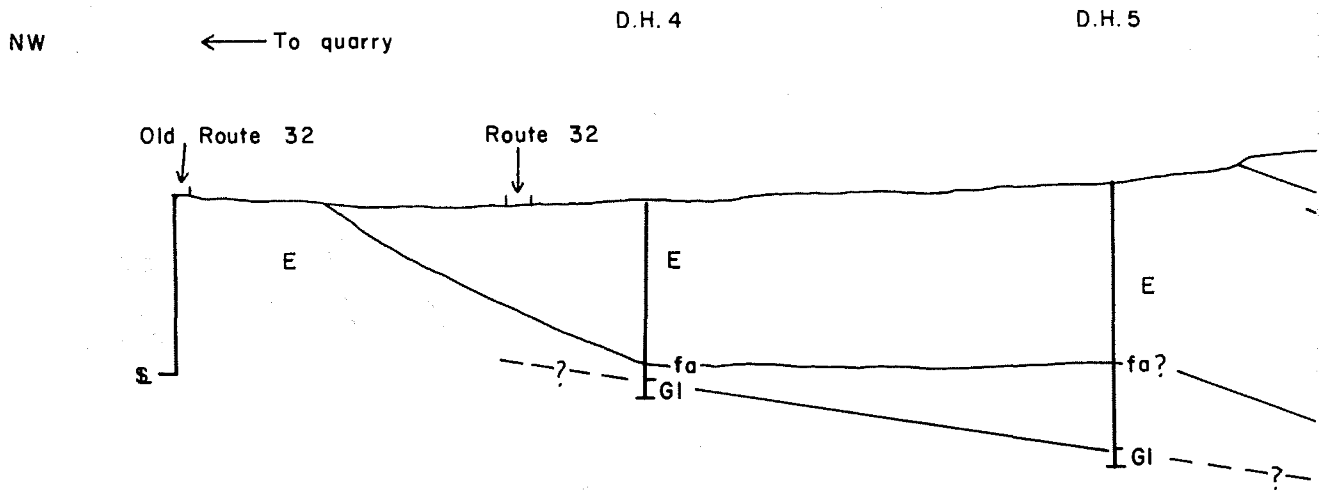
——— floor, lower level (mine entrance)

Binnewater Formation

Cumulative Mileage	Distance between points	
		<u>Time: 4:00 P.M.</u>
56.0		Retrace route past office and mill.
56.9	0.9	Turn right on Sawdust Ave., returning to Keator's Corner.
57.3	0.4	Keator's Corner. Stop sign. Turn right on Binnewater Road.
58.2	0.9	Turn sharp left at stop sign onto Route 213, returning to Rosendale.
59.0	0.8	Turn south (right) on Route 32 and follow signs for the N.Y. Thruway.
59.2	0.2	Abandoned natural cement mine on left.
61.4	2.2	Bridge across the Wallkill River.
62.8	1.4	Good view of Shawangunk Mts. on right.
65.3	2.5	Entering New Paltz.
65.9	0.6	Continue straight on Route 208.
66.1	0.2	East (left) on Main Street (Routes 299 and 32). Follow uphill through village of New Paltz
66.5	0.4	Traffic light. Continue straight on Route 299 (leaving Route 32) to Thruway interchange 18.
67.4	0.9	Enter N.Y. Thruway on right, proceed south to Newburgh (Exit 17) and Holiday Inn.
83.4	16.0	Holiday Inn.

FIGUR

Geologic section across (
southwest of
(after J. H.



E	Esopus Formation
Gl	Glenerie Formation
Co	Connelly Formation
PE	Port Ewen Formation
B	Becraft Formation
NS	New Scotland Formation
K	Kalkberg Formation
C	Coeymans Formation
M	Manlius Formation
R	Rondout Group
SL	Sea Level
	Anticlinal Axis
	Synclinal Axis

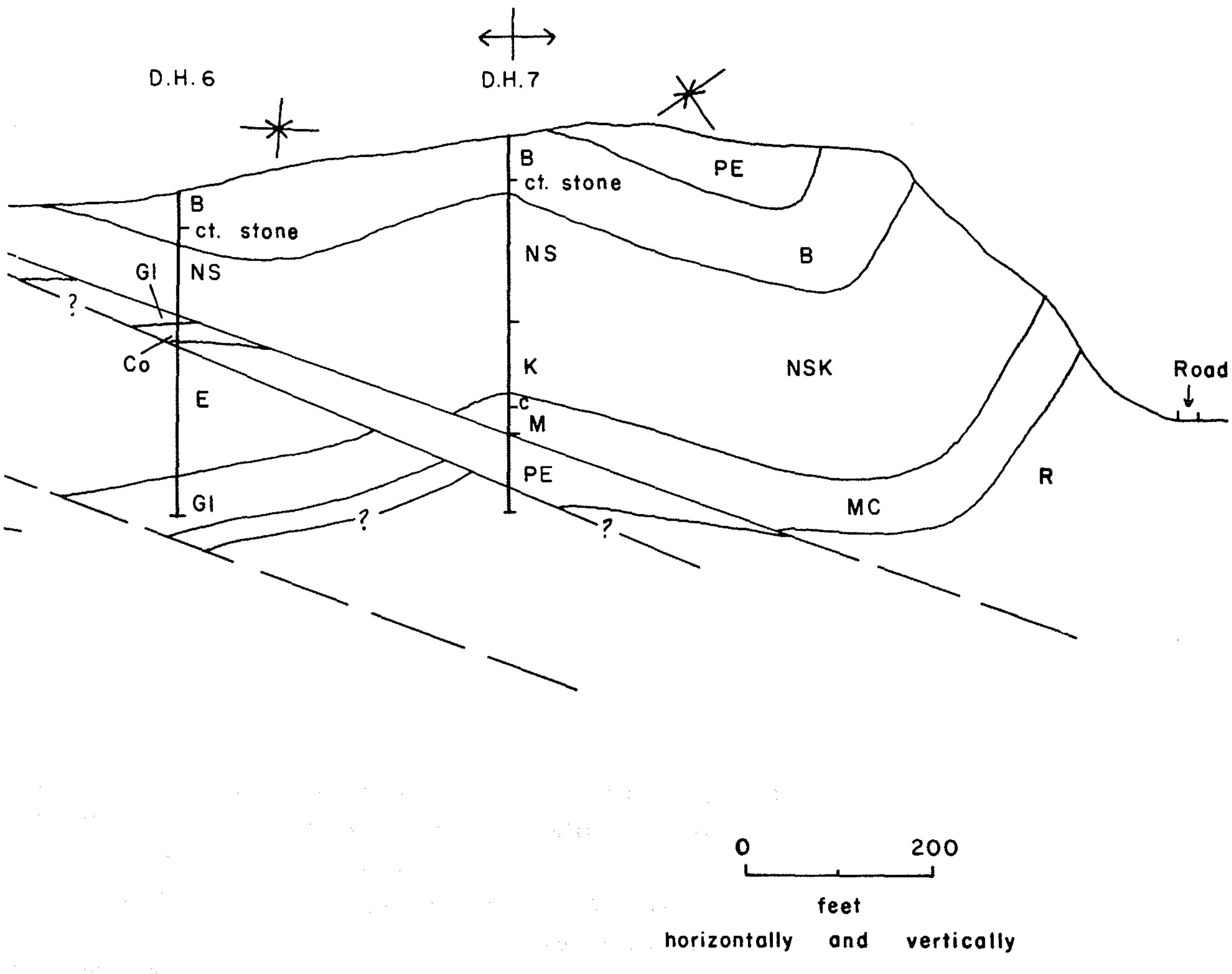
for more complete legend information see Figure B3

' B4

ly Mountain 1,500 feet

Figure B3

Johnsen)



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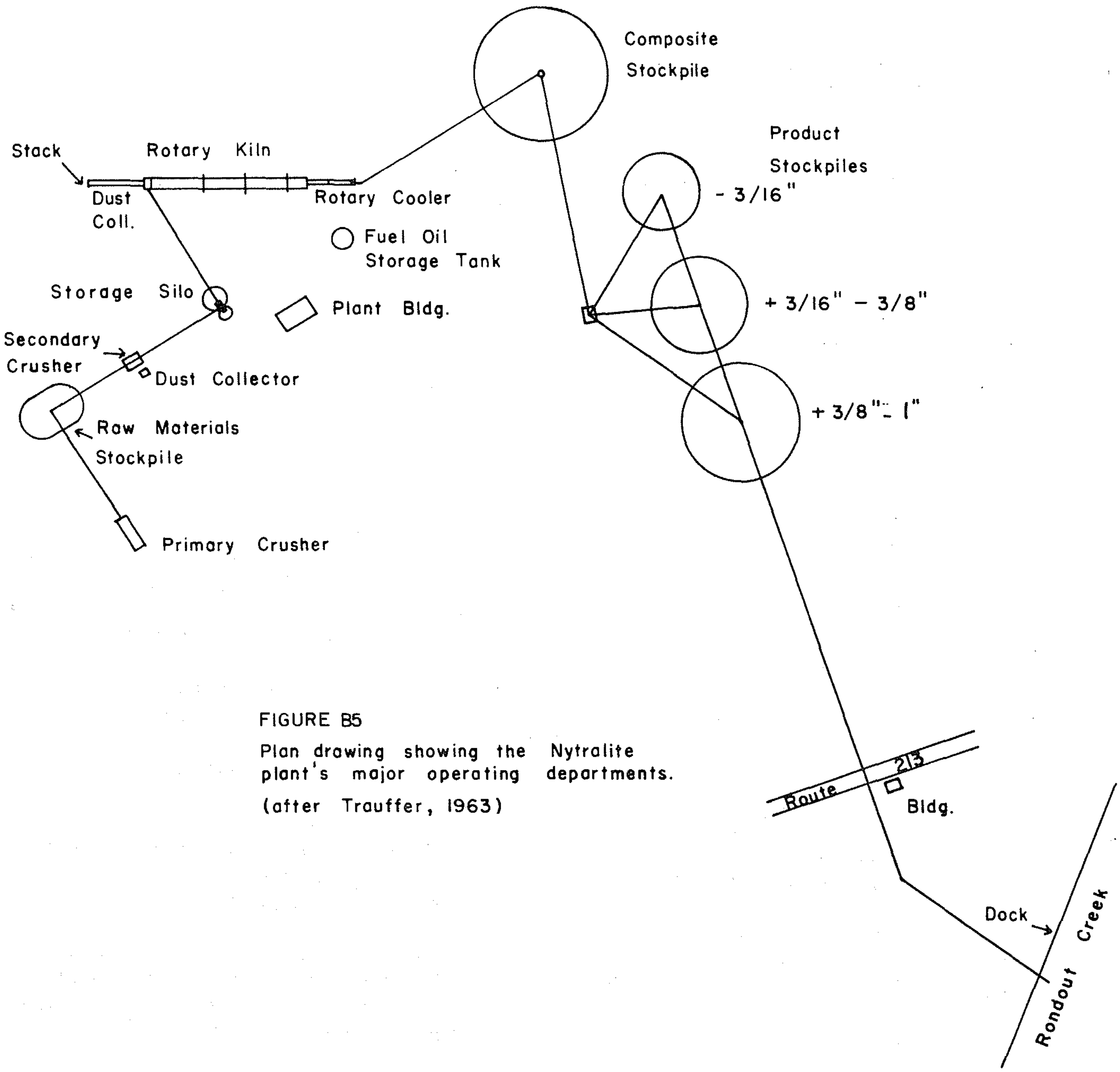

FIGURE B5
Plan drawing showing the Nytralite plant's major operating departments.
(after Trauffer, 1963)

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TABLE B1

GENERALIZED GEOLOGIC SECTION FOR THE MID-HUDSON VALLEY

FORMATIONS (Thickness in feet)	PRINCIPAL LITHOLOGY
DEVONIAN PERIOD	
Middle Devonian	
Plattekill Fm. (800)	Reddish-purple mudstones and siltstones, dark-gray shales and impure sandstone
Ashokan Fm. (300)	Bluish-gray sandstone (flagstone), olive-gray shale
Mt. Marion Fm. (800)	Gray sandstone and shale
Bakoven Fm. (200)	Black shale
Onondaga Fm. (170-180)	
Moorehouse Member (100+)	Gray limestone with dark-gray chert
Nedrow Member (35)	Gray limestone
Edgecliff Member (35-40)	Gray coralline limestone with light-gray chert
Lower Devonian	
Schoharie Fm. (74-222)	
Saugerties Member (18-77)	Medium-gray argillaceous limestone and calcareous mudstone
Aquetuck Member (30-45)	Calcareous mudstone and siltstone with some gray argillaceous limestone; occ. chert
Carlisle Center Member (26-124)	Calcareous dark-gray siltstone and mudstone
Esopus Fm. (150-200)	Dark-gray shale and siltstone
Glenerie Fm. (20-55)	Dark-gray siliceous limestone with chert
Connelly Fm. (0-20)	Gray conglomerate and sandstone
Port Ewen Fm. (10-100+)	Gray argillaceous limestone with interbedded shale
Alsen Fm. (20-25)	Dark-gray limestone with some chert
Becraft Fm. (35-50)	Gray to pinkish-gray crinoidal limestone
New Scotland Fm. (95-150)	Dark-gray calcareous mudstone and argillaceous limestone
Kalkberg Fm. (75)	
Broncks Lake Member (43)	Gray argillaceous limestone and limestone with some dark-gray calcareous shale
Hannacroix Member (32)	Dark-gray to gray limestone, gray shale partings, chert at base
Coeymans Fm.	
Ravena Member (20-28)	Medium-gray to gray limestone
Manlius Fm.	
Thacher Member (48-50)	Dark-gray to medium-gray limestone, occ. laminated; magnesian at base

Compiled by J.H. Johnsen 4/67

SILURIAN PERIOD	
Upper Silurian	
Rondout Fm. (30-55)	
Whiteport Member (4-16)	Gray argillaceous magnesian limestone
Glasco Member (10-13)	Gray coralline limestone
Rosendale Member (6-27)	Gray argillaceous magnesian limestone
Wilbur Member (4-12)	Medium-to light-gray limestone
Binnewater Fm. (0-35)	Blue-gray to greenish-gray cross-bedded, occ. ripple-marked quartz sandstone
High Falls Fm. (0-85)	Red and green shale
Middle Silurian	
Shawangunk Fm. (0-6004)	Milky white to gray quartzite and quartz pebble conglomerate

MAJOR UNCONFORMITY

ORDOVICIAN PERIOD	
Middle Ordovician	
Normanskill Fm. (2000)	
Austin Glen Member (1200+)	Graywackes, black and gray shale and siltstones
Mount Merino Member (250+)	Black shale and chert with local red and green shales
Lower Ordovician	
Stockbridge Group (Wappinger carbonate sequence)	
Balmville Fm. (70)	Gray limestone
Copake Fm. (400)	Dark-gray dolomite with some limestone
Rochdale Fm. (750)	Light-blue-gray limestone, some dolostone
Halcyon Lake Fm. (350)	Light-gray dolimitic limestone
CAMBRIAN PERIOD	
Upper Cambrian	
Stockbridge Group (con'd.)	
Briarcliff Fm. (700)	Light-gray dolostones
Pine Plains Fm. (1475)	Light-gray, slightly sandy dolostone, some sandstone and shale
Middle and Lower Cambrian	
Stissing Fm. (500)	Gray dolostone, some with chert
Lower Cambrian	
Poughquag Fm. (300)	Gray quartzite

MAJOR UNCONFORMITY

PRECAMBRIAN (exposed in the Hudson Highlands)

TABLE B2

USES OF THE ROCK FORMATIONS IN THE MID—HUDSON VALLEY

Plattekill Fm.	Extruded wire cut brick
Ashokan Fm.	Flagstone
Mt. Marion Fm.	Extruded wire cut brick, argillaceous component in portland cement
Onondaga Fm.	Crushed stone, portland cement, locally blast furnace flux and agricultural limestone
Esopus Fm.	Lightweight aggregate, argillaceous component in portland cement
Glenerie Fm.	Crushed stone, portland cement*
Port Ewen Fm.	Crushed stone, portland cement*
Alsen Fm.	Crushed stone, portland cement*
Becraft Fm.	Portland cement, crushed stone, agricultural limestone
New Scotland Fm.	Crushed stone, portland cement*
Kalkberg Fm.	Crushed stone, portland cement*
Coeymans Fm.	Crushed stone, portland cement*
Manlius Fm.	Crushed stone, portland cement, blast furnace flux, agricultural limestone
Rondout Fm. (Rosendale & Whiteport Members)	Natural cement
Normanskill Fm.	Extruded wire cut brick, possibly lightweight aggregate
Briarcliff Fm.	Crushed stone, riprap
Pine Plains Fm.	Crushed stone, riprap

*When mixed with purer limestones such as Becraft, Coeymans or Manlius

MIDDLE AND UPPER DEVONIAN CLASTICS OF THE CATSKILL FRONT. NEW YORK

FRANK W. FLETCHER
Susquehanna University

STRATIGRAPHY

Introduction

The Middle and Upper Devonian of the Catskill Mountains region of southeastern New York consist of approximately 8000 feet of strata which commence with limestones at the base and grade upward through black shales, gray siltstones, gray sandstones, red beds, and, at the top, conglomerates (Fig. 3). The lowermost 2000 feet (Onondaga, Bakoven, and Ashokan Formations) are described by Chadwick (1944, p. 94-116). The purpose of this field trip is to examine the red bed—gray sandstone and conglomerate facies or depositional phases (Rickard, 1964) that have been referred to as "Catskill."*

Detailed Stratigraphy

PLATTEKILL FORMATION

The oldest red-bed formation in this area is the Plattekill, which is characterized by three tongues of grayish-red (10 R 4/2) claystone and shale interbedded with medium-dark-gray (N4) shale and cross-bedded sandstone. The base of the Plattekill Formation is drawn at the base of the lowest red bed, because the gray shales and sandstones are indistinquishable from those of the Ashokan Formation. The Plattekill Formation is named for exposures in Plattekill Creek at West Saugerties, New York (Kaaterskill quadrangle). The name was introduced to replace, in part, "Kiskatom" which was employed by Chadwick (1933, p. 482) for alleged Hamilton non-marine strata (Fletcher, 1962, p. D3).

The formation has a maximum thickness of 1000 feet at the Catskill Front, but thins rapidly westward because of the wedging-out of the two lowest tongues (Fig. 5). The lowest tongue is only 125 feet thick and is difficult to trace on the surface. The middle tongue is thicker and can be identified both on the surface and in the subsurface by the presence of two thin, light-gray sandstones which contrast markedly with the more common dark-gray sandstones. The upper tongue measures 250 feet at the Catskill Front, but thins to a feather-edge in the subsurface near Margaretville. The most complete exposures of this tongue are located in Plattekill Clove and Kaaterskill Clove.

The lowermost 690 feet of the Plattekill is composed of medium-dark-gray (N4) shales, siltstones and fine-and medium-grained subgraywackes. Interbedded fine-grained, grayish-red (5 R 4/2) sandstones, shales, and claystones are present in minor quantities and are concentrated in the three tongues described above. Red beds in this part of the Plattekill do not exceed 10 feet in thickness and average five feet. A distinctive medium- to coarse-grained, light-medium-bluish-gray (N7-5B7/1) subgraywacke sandstone and grayish-black (N2) to medium-dark-gray (N4) shale interval lies approximately 800 feet below the top of the formation and serves as a useful marker bed for the lower part of the unit at the Catskill Front (Lucier, 1966, p. 8). The upper 300 feet is composed almost entirely of grayish-red shales, siltstones, and claystones (the upper tongue). Sedimentary cycles (Fig. 6) are well-developed in the red-bed portions of the Plattekill and are composed of a fining-upward sequence of sandstone (gray or red), at the base, followed by red siltstone, red shale and claystone, and, at the top, a thin layer of greenish-gray claystone. The cycles are generally less than 20 feet in thickness.

*Rickard (1964) calls the conglomerate phase "Pocono."

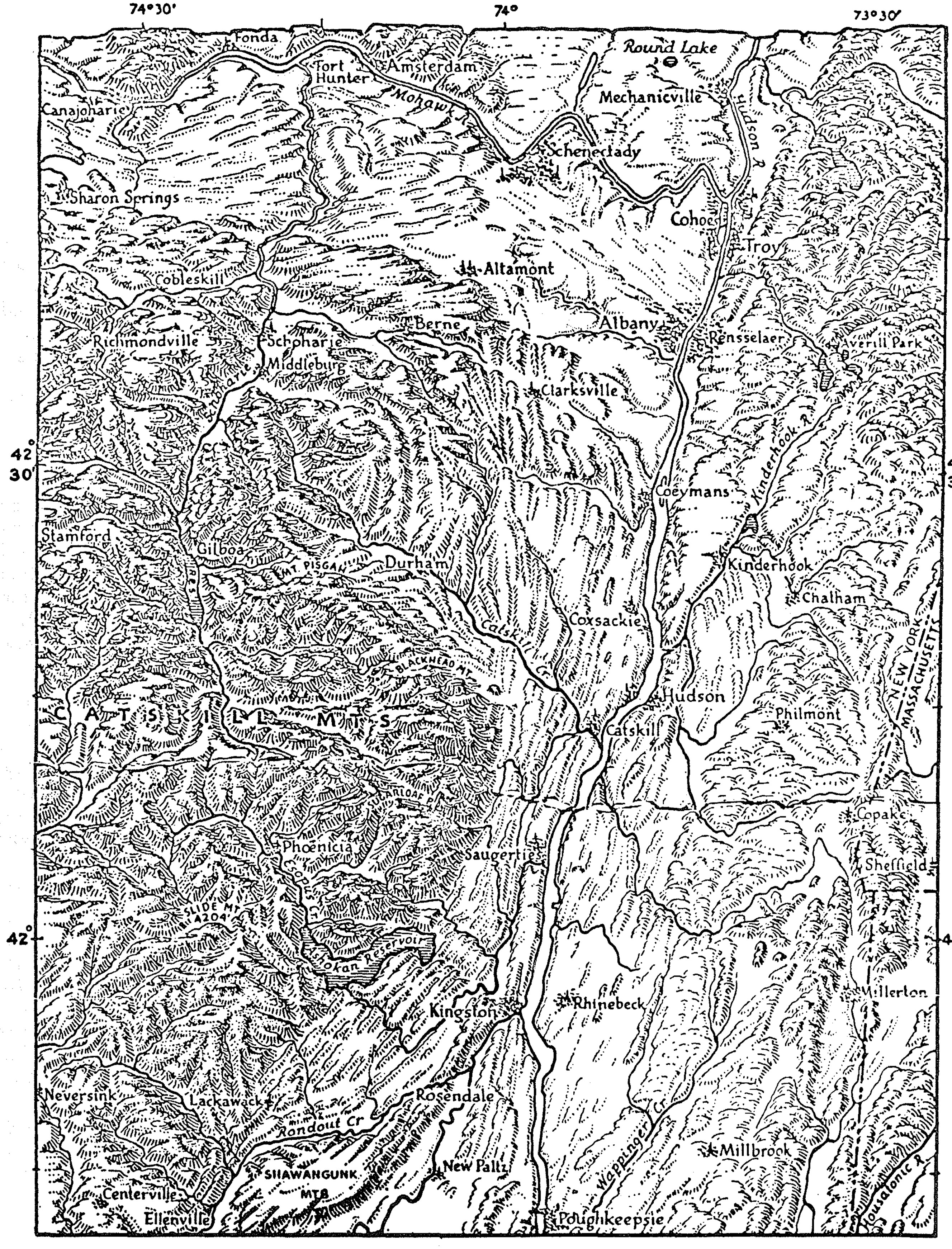


Figure 1. Physiography of the Catskill Front and the Hudson Valley (from Berkey, 1933).

POTTER HOLLOW FORMATION

The Plattekill is overlain by the Potter Hollow Formation which consists of medium-dark-gray (N4) shales and subgraywackes, and smaller amounts of very distinctive light-olive-gray (5 Y 5/2) sandstones. It is 250 feet thick in the subsurface at Phoenicia, New York and contains a substantial amount of shale. The Potter Hollow thins to 212 feet and becomes more sandy at the Catskill Front where it forms a continuous ridge between the 1390 and 1580 foot elevations. The upper and lower contacts of the unit are sharply delineated by the red-bed lithologies of the Manorkill and Plattekill Formations respectively.

The Potter Hollow Formation originally was believed to be an easterly extension of part of the Gilboa Formation (Fletcher, 1963, p. 32), but subsequent field tracing has established that it is an easterly tongue of the Cooperstown Formation (Fig. 5). The Portland Point Limestone of the upper Hamilton lies within the Potter Hollow. Extensive and detailed studies by McCave (1965, p. 103) have greatly increased our knowledge of this unit.

MANORKILL FORMATION

The Manorkill Formation, like the Plattekill, is distinguished by the presence of red beds although it is thinner than the Plattekill. The sandstones of the Manorkill also serve to characterize the formation. They are fine-grained, medium-dark gray (N4) in the lower half, but medium-grained and medium gray (N5) in the upper half. The Manorkill can be recognized, therefore, everywhere along the Catskill Front by the presence

Mather 1840	Chadwick 1933	Chadwick 1936	Fletcher 1963	Fletcher this report
Catskill Mountain Series	Catskill	Slide Mt.	Wittenberg	Slide Mt.
		Wittenberg Katsberg Stony Clove		
			Walton	Walton
	Oneonta	Oneonta Onteora	Twilight Park	Oneonta Twi. Pk.
	Kiskatom	Kaaterskill Kiskatom	Oneonta	
			Gilboa	Gilboa
				Manorkill
				Potter Hollow
			Plattekill	Plattekill
	Lower Hamilton	Ashokan	Ashokan	Ashokan
		Mt. Marion	Mt. Marion	Mt. Marion
		Bakoven	Bakoven	Bakoven

Figure 2. Comparative stratigraphic nomenclature for the Catskill Front.

	FORMATION	LITHOLOGY	SEDIMENTARY STRUCTURES	X-BEDDING MEANS
8000 / 7000	SLIDE MOUNTAIN	Gray conglomerate	Cross-bedding	268
6000	WALTON	Red beds; medium-gray coarse-grained sandstone	Cross-bedding	275
5000	MIDDLESEX	Dark-gray shale and sandstone; fossils	Cross-bedding	
	ONEONTA	Red beds; medium-gray, medium-grained sandstone	Cross-bedding	315
4000	GRAND GORGE	Dark-gray shale and sandstone; protoquartzite	Pillow structures	284
	MANORKILL	Red beds; gray, fine-grained sandstone	Ripplemarks	295
3000	POTTER HOLLOW	Dark gray shale and sandstone; protoquartzite	Pillow structures	296
	PLATTEKILL	Red beds; medium-dark-gray sandstone	Cross-bedding	289
2000	ASHOKAN	Dark-gray sandstone	Cross-bedding	
1000	MOUNT MARION	Dark-gray shale and sandstone; fossils	Pillow structures	
	BAKOVEN	Black shale		
0	ONONDAGA	Limestone		

Figure 3 Idealized composite stratigraphic column of the Catskill Mountains region (slightly modified from Fletcher, 1964).

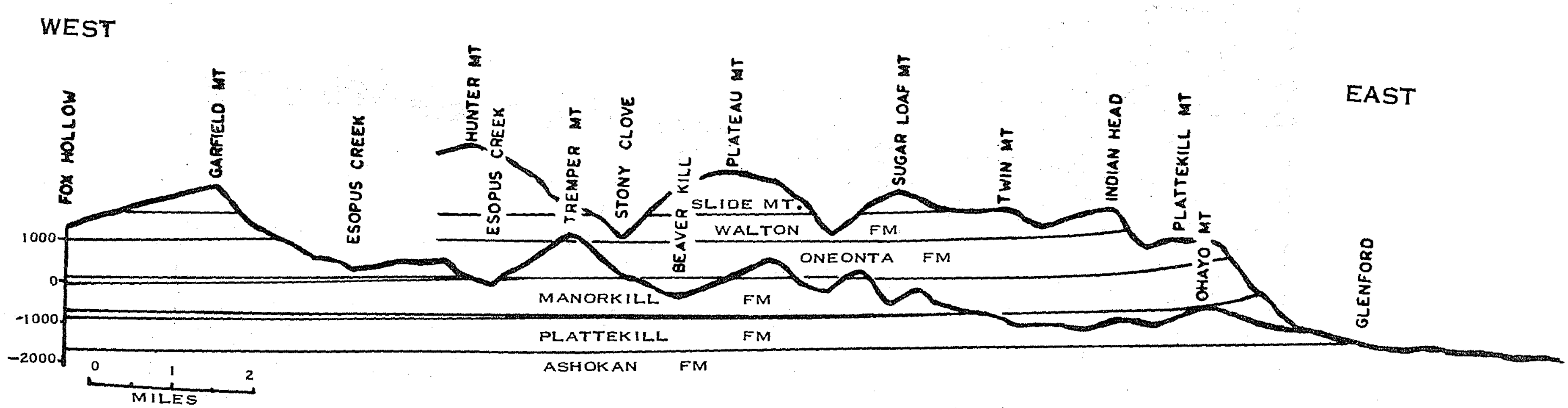


Figure 4 Geologic cross-section of the Catskill Front.

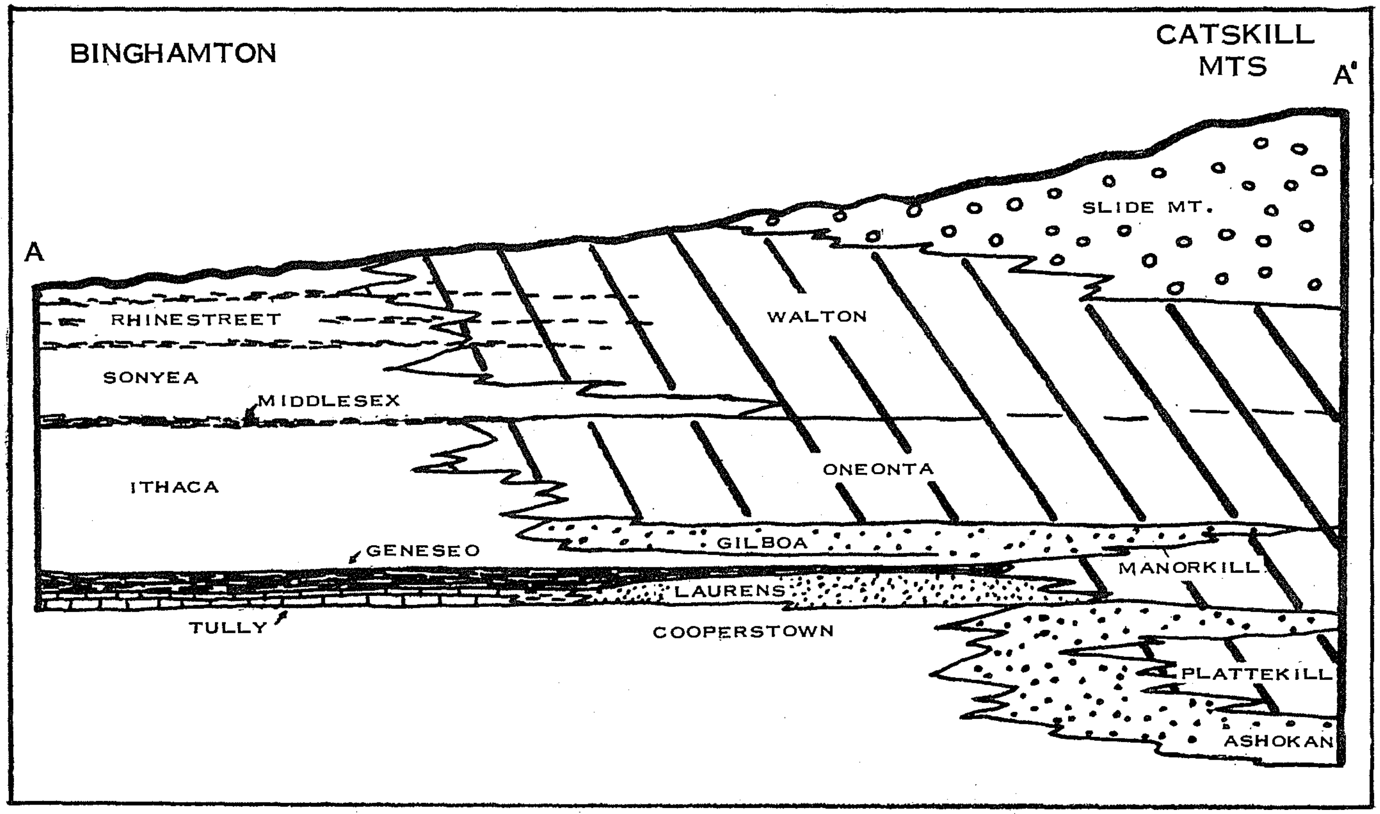


Figure 5 Diagram of marine and non-marine facies relationships. Major red-bed tongues are shown by diagonal lines (modified from Woodrow and Fletcher, 1967 after Fletcher, 1964).

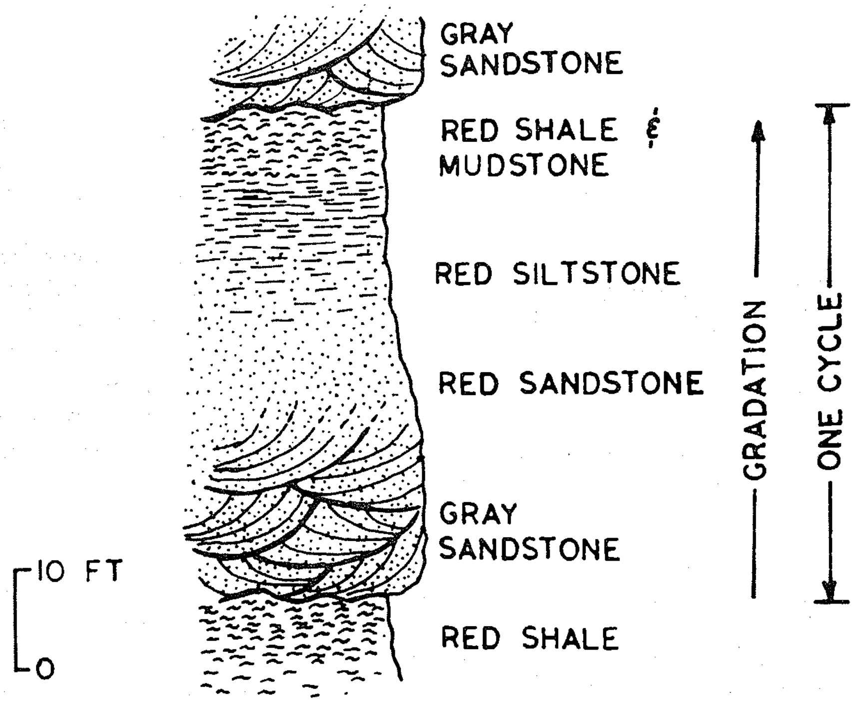


Figure 6 SEDIMENTARY CYCLE

of these two facies. Red beds are the dominant rock type in the formation and consist of brownish-gray (5 YR 4/1) to grayish-red (10 R 4/2) shales, claystones, siltstones and fine-grained sandstones. Sedimentary cycles commonly exceed 50 feet in thickness.

The Manorkill Formation is approximately 620 feet thick and forms much of the Catskill Front. The lower boundary of the unit is drawn at the base of 37 feet of red shale and siltstone that overlie the gray sandstones of the Potter Hollow Formation. The upper contact is marked by the termination of 80 feet of red shale, claystone and siltstone (Lucier, 1966, p. 9). Field tracing of the Laurens Sandstone of the Tully Formation into Schoharie Creek from the west has demonstrated that the Manorkill is the eastern equivilent of the Laurens (Fig. 5). The type section of the Manorkill is the creek of the same name adjacent to the Schoharie Reservoir (Fletcher, 1963, p. 32.)

GILBOA FORMATION

The Gilboa Formation in the region of the Catskill Front consists of interbedded medium-gray (N5), cross-bedded subgraywackes and medium-dark-gray (N4) shales and siltstones. Although it measures only 44 feet in Kaaterskill Clove, it is readily recognized by the presence of a 15-foot dark-gray siltstone bed that contains pillow structures ("flow rolls"). This bed is the only one of its kind above the Ashokan Formation and thus serves as a useful marker in the thick red-bed sequence at the Catskill Front. The Gilboa can be recognized along the old cog-hill railway up to the site of the famous Catskill Mountain House (now North Lake State Park) by 1.5 feet of distinctive, whitish-weathering siltstone.

The siltstone unit was called the Grand Gorge Member of the Gilboa Formation by Fletcher (1963, p. 34) before correlation between Schoharie and Kaaterskill Creeks had been definitely established. It seems best, now, simply to recognize it as an easterly-extending tongue of the Gilboa Formation (Fig. 5).

ONEONTA FORMATION

Overlying the Gilboa and forming the rimrock of the Catskill Front is the lowest 280 feet of the Oneonta Formation. These rocks, to the base of the Twilight Park conglomerate formed the Kaaterskill Sandstone of Willard (in Chadwick, 1936, p. 74). The entire thickness of the Oneonta is approximately 900 feet and the base of the unit is drawn at the red beds that directly overlie the Gilboa Formation.

The Oneonta is a sequence of grayish-red (5 R 4/2) sandstones, siltstones, shales, and claystones and of coarse-grained, medium-gray (N5), cross-bedded sandstones with scattered quartz pebbles. Red beds comprise 44 percent of the formation and fining-upward cycles may exceed 80 feet in thickness (Lucier, 1966, p. 11). The Oneonta may be distinguished from the older red-bed units because its sandstones are lighter colored and coarser grained. Approximately 100 to 200 feet of massively - and cross-bedded conglomerate form a prominant topographic bench along the top of the Catskill Front and form the caprock of South Mountain. This is the Twilight Park conglomerate of Prosser (1899). It is one of the most diagnostic features of the Oneonta and marks the lowest major zone of pebbles in the section. Recent work by Buttner (personal communication) has brought to light the complex geologic history of this conglomerate and casts doubt on the validity of assigning formal stratigraphic rank to it.

WALTON FORMATION

Chadwick (1933, p. 483) proposed the name "Onteora" for the strata between the Twilight Park conglomerate and his Stony Clove Sandstone in the vicinity of High Peak. The Stony Clove, which Chadwick (1944, p. 130) described as "gray sandstones coarsely flaggy and without a noticeable trace of red color throughout a thickness of eight or nine hundred feet" actually contains three thick zones of red shale and claystone at the type locality. Since it is impossible to distinguish the rocks Chadwick included in the Stony Clove Formation from the zone of red beds that he reported in the basal part of his Katsberg Formation, these two series of strata were combined with Chadwick's Onteora by Fletcher (1963, p. 38) to form a distinctive mappable unit — the Walton Formation. The type locality of the Walton is Bear Spring Mountain, approximately one mile southeast of Walton, New York.

The Walton consists of 1000 feet of red beds, gray sandstones and small amounts of gray shale. Its lowest 100 feet are composed of fine-grained sandstones which represent a marked lithologic change from the coarser-grained, conglomeratic sandstones of the underlying Oneonta Formation. The uppermost sandstones are medium-gray (N5) and greenish-gray (10 GY 5/2) and coarse-grained. These beds are conglomeratic and contain pebbles of dark-gray (N3) and white quartz and light-gray (N7) chert. The conglomeratic sandstones grade upward into the overlying Slide Mountain Formation. The transition can be observed readily on the flanks of Wittenberg and Hunter Mountains.

SLIDE MOUNTAIN FORMATION

The youngest formation in the area is the Slide Mountain. The name was proposed by Chadwick (1933, p. 480) and was restricted originally to the uppermost 400 feet of strata on Slide Mountain. Chadwick believed these to be correlative with "Chemung." Because there is no difference between the top 400 feet of conglomerate and any of the underlying 1600 feet of rock, Fletcher (1964a) redefined the unit to include all the strata above the Walton. The name "Wittenberg" had been employed earlier by Fletcher (1963, p. 39) for these same conglomerates because of the excellent exposures on the flanks and top of Wittenberg Mountain. Although the boundary between the Slide Mountain and the underlying Walton Formation is gradational through approximately 300 feet, the Slide Mountain can be identified by the predominance of conglomerate and the paucity of red claystone.

Lithologically the Slide Mountain consists of cross-bedded, yellowish-gray (5 Y 7/2) conglomerate. Its pebbles are of milky quartz and red and yellowish-gray sandstone. Maximum diameter is 100 mm. This unit caps all the highest peaks of the Catskill Mountains.

PALEOGEOGRAPHY

Environments of Deposition

Twelve major rock-types can be recognized in the Catskill Mountains region and they form three distinct facies: 1) marine, 2) transition, and 3) continental (Table 1). Each facies is the record of a specific environment that has been determined by comparison with analogous modern environments on the basis of compositional, textural, and structural criteria. These criteria are discussed by: Dunbar and Rodgers (1957), Fisk, McFarlan, Kolb, and Wilbert (1954), Fischer (1961), and Allen (1965), and are summarized in Table 1.

Sedimentation Patterns

Figures 3 and 5 show that no simple vertical and lateral change from marine to non-marine conditions occurred in the basin of deposition during the Middle and Late Devonian, but that the complex intertonguing of facies is a record of rhythmic transgressive and regressive sedimentation. Three orders of cyclic sedimentation can be distinguished within the facies patterns.

FIRST-ORDER CYCLE

The first-order cycle is the thinnest, commonly 50 to 100 feet, and consists of the fining-upward cycle described in Figure 6. Comparison of cyclothemic sedimentation in other parts of the geologic record suggests that a common causal control exists and that lithologic differences reflect differences in depositional environment.

Cyclic Deposit	Environment	Reference
S.E. New York (Dev.)	Alluvial plain	Fletcher (1964a)
Dunkard (Perm.)	Transition	Beerbower (1961)
Illinois (Penna.)	Transition	Weller (1956)
Kansas (Penna.)	Marine	Moore (1936)

The absence of limestone, coal and other typical cyclothem members in these Devonian cycles indicates that the cycles were formed on an alluvial plain and not in the transition zone where swamps, lagoons and barrier bars are present. It is inferred from the similarity between the Catskill cycles and those described by Allen (1962 and 1964) that the cycles originated from fluviatile deposition on an alluvial plain. The rock-types, the common cross-bedding and the poor to moderate sorting of the sandstones are similar to features of modern braided stream deposits (Doeglas, 1962, p. 188-190). The distributary system of the Catskill cycles was composed, apparently, of short high-gradient streams. The relatively small variability of cross-bedding directions suggests also high-gradient stream deposition, for meandering would tend to increase cross-stratification variability as a function of local point-bar accumulation (Lucier, 1966, p. 84).

A possible sedimentologic interpretation for the cycles can be proposed in light of two studies in modern sediments: Fischer (1961) in the New Jersey Coastal Plain, and Fisk and McFarlan (1955) in the Quaternary Mississippi delta. The stages of development of the alluvial plain cycles are summarized as follows:

(1) Base level at minimum. Gradient and competence of streams at maximum. Erosion of alluvial plain and deposition on slope. Slope builds out into basin.

(2) Base level rising. Gradient and competence of streams reduced progressively. Coarse, poorly-sorted sands with quartz and shale pebbles at base deposited on alluvial plain. Gradation upward to finer-grained silts and clays as base level rises.

TABLE 1

LITHOLOGY	SEDIMENTARY STRUCTURES	TYPICAL FOSSILS	ENVIRONMENT
Dark gray shale	---	Pelecypods	
Dark gray siltstone	Pillow structures	---	MARINE
Dark gray sandstone	Flaggy-bedding	Brachiopods	Infralittoral
Arenaceous coquinite	---	Brachiopods	
Protoquartzite	Cross-bedding	Plants	TRANSITION Littoral
Mottled siltstone	Ripple-marks	---	Tidal Flat
Gray sandstones	Cross-bedding	Plants	
Red sandstone	Cross-bedding	---	
Red siltstone & shale	---	---	
Red mudstone	Disturbed bedding	---	CONTINENTAL
Greenish-gray, conglomeratic sandstone	Cross-bedding	---	
Gray & red conglomerate	Cross-bedding	---	

(3) Base level at maximum. Gradient and competence of streams at minimum. Oxidation of muds exposed to atmosphere to red soil. Layering in uppermost muds destroyed by burrowing worms and other organisms, dessication cracks, and plant roots; swamps formed locally.

(4) Base level lowering. Streams rejuvenated. Alluvial plain eroded by entrenched streams that are located in restricted channels. Entrenchment of streams lowers water-table enabling oxidation to occur to depths of 30 to 40 feet below surface of plain.

The ultimate cause of the change in base level could have been eustatic change in sea level or tectonic (i.e., differential uplift in the source and/or subsidence in the basin of deposition). In light of the nature of the second- and third-order cycles described below, tectonic control seems most probable.

SECOND-ORDER CYCLE

The second-order cycle is represented by the alternation between marine and nonmarine facies in vertical section.

Walton Fm.	REGRESSION
Middlesex Fm.	TRANSGRESSION
Oneonta Fm.	REGRESSION
Gilboa Fm.	TRANSGRESSION
Manorkill Fm.	REGRESSION
Potter Hollow Fm.	TRANSGRESSION
Plattekill Fm.	REGRESSION

The regressive phase of the cycle is typically the thickest (600 to 1500 feet). Deposition of cross-bedded, gray sands preceded deposition of the red beds and the older red beds of any red-bed formation do not extend into the basin as for as the younger ones (e.g. Plattekill Formation). The lower boundary of any regressive tongue "rises" stratigraphically toward the basin interior, whereas the upper boundary is abrupt. This suggests that the regressive stages were long-lived in contrast to the short-lived, thin (100 to 300 feet) transgressive stages. The stages of development of the second-order cycle are:

(1) Sands, derived from up-lifted source area, deposited on alluvial plain, which builds out gradually into the basin.

(2) Red beds developed above gray sands; they also migrate toward basin interior. Sediment supply reduced and subsidence exceeds deposition.

(3) Sea transgresses and dark gray shales deposited.

These cycles reflect intermittent uplift in the source area and relatively continuous subsidence in the basin. The amount of sedimentary detritus from the source area is determined by the changes in the rate of uplift. Variability in the rate of uplift was chiefly responsible for the alternate episodes of regression and transgression. Figure 7 shows the paleogeography of the region during the late Middle and early Late Devonian.

THIRD-ORDER CYCLE

The thickest cycle, 8000 feet at its maximum along the Catskill Front, is a composite of a number of second-order cycles and represents the combined effect of the smaller scale uplifts. It is an example of the geosynclinal cycle of Pettijohn (1958, p. 637).

Lithology	Principle Facies	Example
Coal	Molasse	Not present in New York
Conglomerate	Molasse	Slide Mt. Fm.
Red beds	Molasse	Plattekill through Oneonta Fm.
Gray sandstone and shale	Flysch	Mount Marion Fm.
Black shale	Euxinic	Bakoven Fm.
Limestone	Pre-orogenic	Onondaga Fm.

This cycle shows two major patterns: (1) general increase in grain size upward, and (2) change from marine to non-marine conditions upward. It represents over-all general uplift in the source area and subsidence in the basin, but subsidence was generally slower than uplift, which caused the westward shift of the facies with time (Fig. 7).

Source Area

The three most intensive studies of the provenance of the Catskill sediments have produced divergent hypotheses. The earliest study led to the postulation of a source area located east and southeast of the Catskill Front at a distance greater than 100 miles and in an area of Precambrian crystalline rocks. This source area, called Appalachia, was inferred to be a great mountain system occupying parts of eastern Connecticut and the region now overlain by the Coastal Plain and portions of the continental shelf sediments (Barrell, 1914, p. 246-247; and Fig. 8). The second study placed the source to the north and east of the Catskill Front at a distance of approximately 50 to 75 miles and in the general region of the Taconic-Berkshire-Green Mountain belt (Mencher, 1939, p. 1779-1782). The third study, based on paleocurrent and petrographic criteria of the Catskill facies, postulates a source area composed of Silurian and Lower Ordovician limestone and argillaceous rocks which presently crop out within 25 miles of the eastern limits of the Catskill Front sediments (Burtner, 1964, p. 189).

The detailed study of Lucier (1966) indicates that supracrustal rocks were the dominant suppliers of sediment throughout the time of deposition of the Catskill facies. There is no petrographic evidence to support the contention that plutonic crystalline rocks or eruptive igneous rocks served as either the dominant or assessory source terrane for the sediments. The evidence for this conclusion is the lack of plutonic or eruptive igneous rock fragments in the sandstones, the general absence of igneous and high-rank metamorphic index minerals in the heavy mineral suite, and the scarcity of feldspar (Lucier, 1966, p. 68).

Within the supracrustal suite two distinct lithologic associations were dominant at different times. Analysis of all mineralogic data indicates that a sequence of interbedded shales and sandstones, perhaps slightly metamorphosed, was the dominant source lithology of the pre-Oneonta sediments. The evidence that supports this contention is dominance of foliated aphanites, the abundance of graywacke sandstone and siltstone fragments and the presence of lesser amounts of chert throughout the section, and the occurrence of rounded zircon, tourmaline and rutile in the heavy mineral suite. The presence of detrital chlorite and muscovite and the persistent inclusion of chlorite within many of the rock fragments indicates that the source terrane was subjected to a very low grade regional metamorphism (Lucier, 1966, p. 70).

The base of the Oneonta Formation, however, is marked by intersecting trends of the foliated aphanites (decreasing) and polycrystalline quartz (increasing) and it is inferred from this that a more quartz-rich source area was being eroded. Metamorphic quartzite containing chlorite and, more rarely, muscovite inclusions was a common rock type in the source terrane. Whereas most of the quartzite pebbles are white, some of those found in the lower Oneonta Formation have a pinkish and greenish tinge. The trace minerals and rock

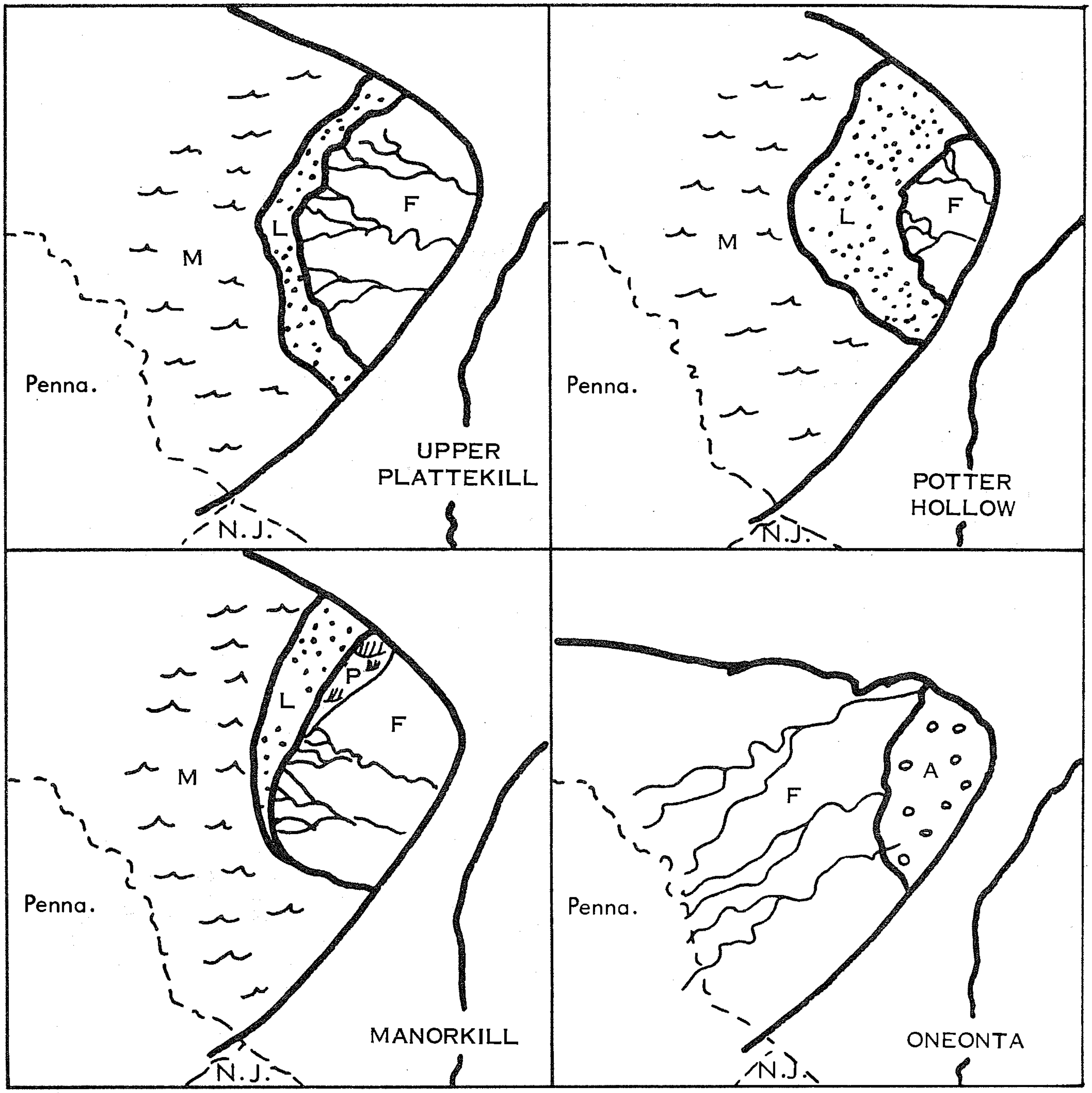


Figure 7 Paleogeographic maps of the Catskill Mountains region, late Middle Devonian and early Late Devonian. Symbols: M : marine, L - littoral, P : paludal, F : fluvial, and A : alluvial plain.

fragments that are more abundant in the Oneonta also suggest a quartzitic source. These include the angular pink-to-green tourmaline, the angular orange rutile, the chlorite-veined quartz, and the red argillite fragments (Lucier, 1966, p. 71). At this time, no detailed petrographic data are available from the Walton and Slide Mountain Formations.

Figure 10 summarizes the stratigraphic section of the source area as inferred from all the field and petrographic information. The section is based on the assumption that the source rocks shed quantities of detritus in proportion to their concentrations in the Catskill facies and in an inverted stratigraphic order. The location of the source is placed east-southeast of the Catskill Front based on the cross-bedding and particle orientation data (Fletcher, 1964b; Lucier, 1966).

The poor to moderate rounding of the detrital minerals and the abundance of labile rock fragments suggest a source in close proximity to the present Catskill Front. Figure 9 shows an area in eastern New York that lies between plus and minus one standard deviation of the cross-bedding mean and includes portions of the Kinderhook and Copake 15-minute quadrangles (Lucier, 1966, p. 74). Figure 11 is an idealized section of the sequence of rocks in this area based primarily on the correlations proposed by Craddock (1957, p. 697-699). Comparison of Figures 10 and 11 indicates that almost all the stratigraphic, lithologic and mineralogic requirements of the source area, as suggested by Lucier's petrographic analysis, are fulfilled by that sequence in eastern New York (Fig. 9).

Lucier (1966, p. 80) concludes that the provenance was that sequence of Lower Cambrian to Middle Ordovician clastics now exposed within 25 miles of the eastern limits of the Catskill Front sediments (Fig. 9). The vertical mineralogic variation evident throughout the Catskill facies' sandstones dominantly reflects the stratigraphic inversion of the Normanskill, Deepkill, and Nassau-Rensselaer sediments and low-rank metamorphics

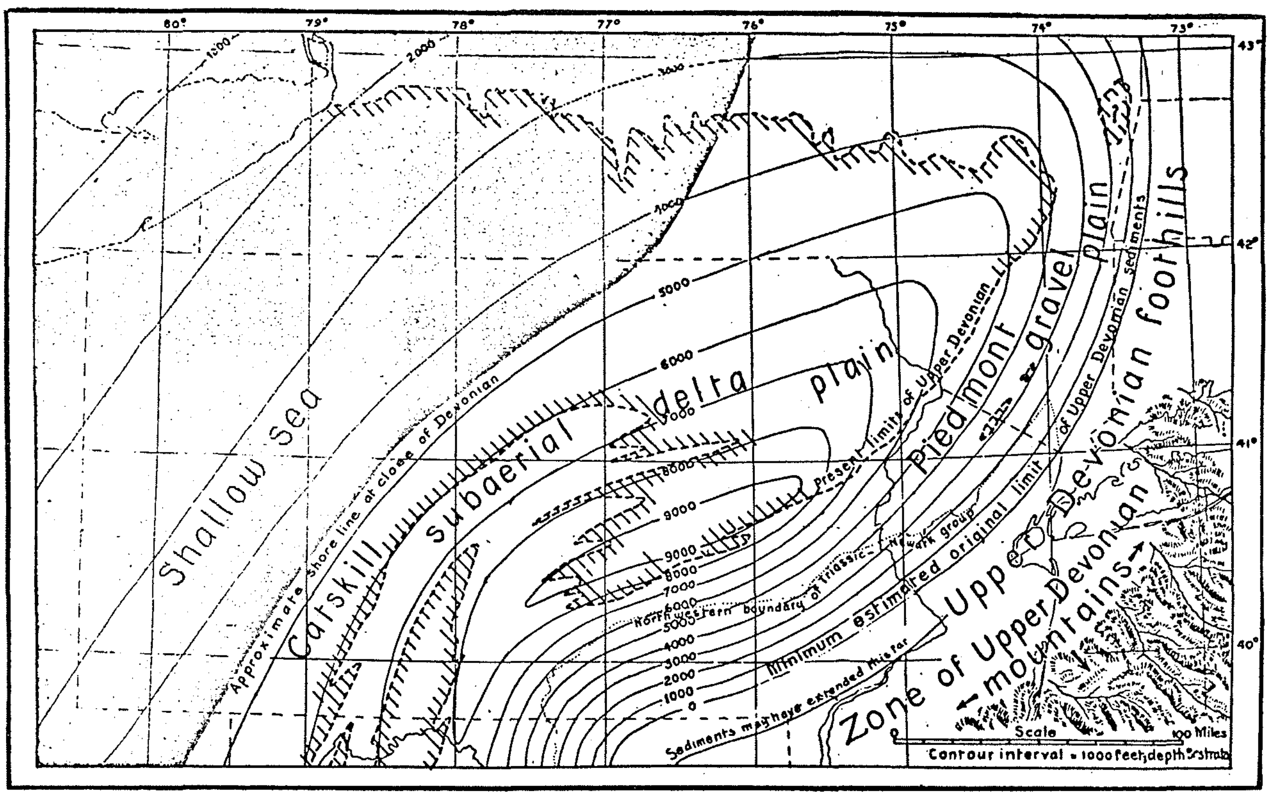


Figure 8. Barrell's interpretation of the Appalachian geosyncline at the close of the Devonian (from Barrell, 1913, Fig. 1, p. 430).

FIGURE 9 POSITION OF SOURCE AREA BASED ON CROSS-BEDDING AND METAMORPHIC ASSEMBLAGES (from Lucier, 1966, Fig. 25)

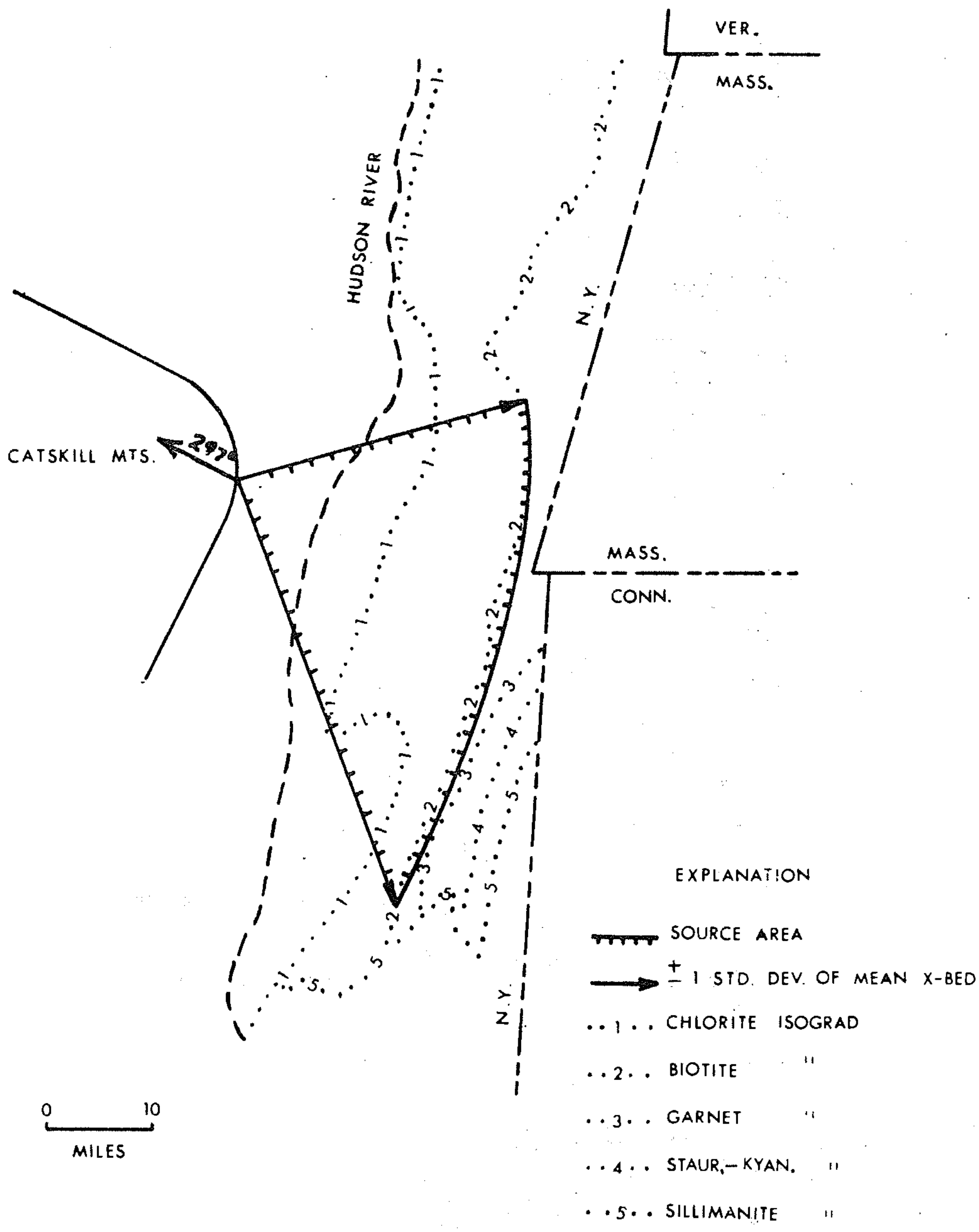
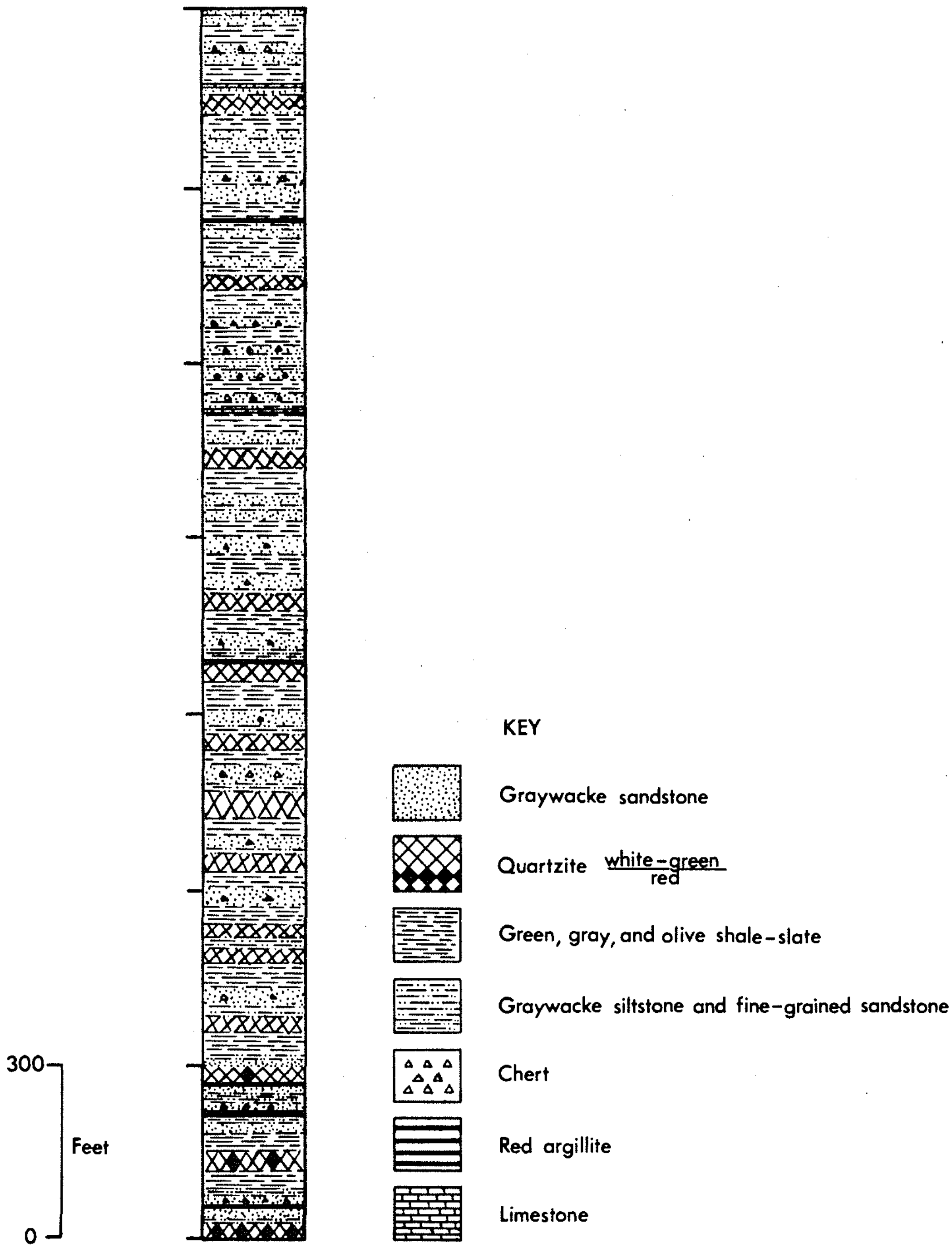
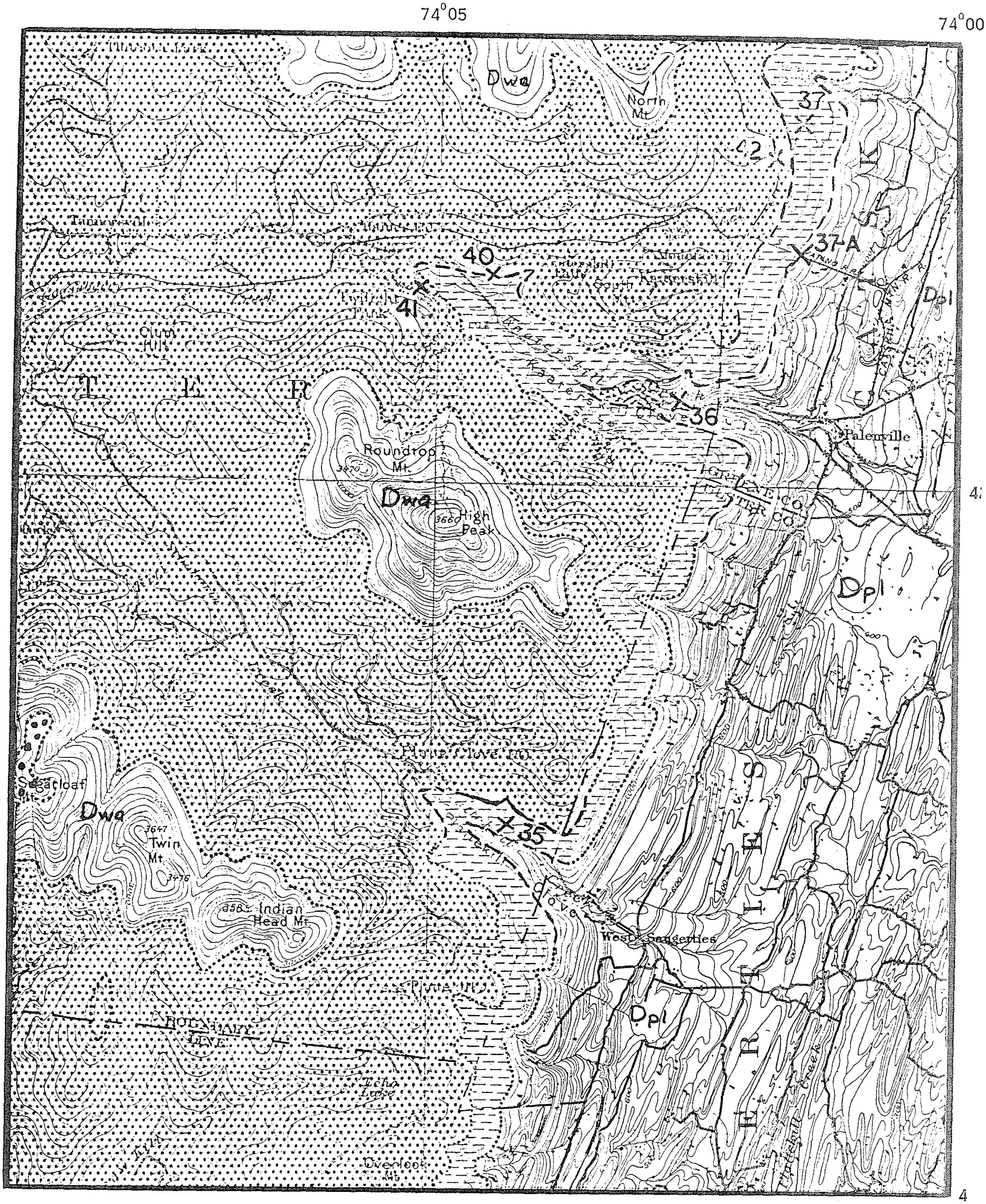


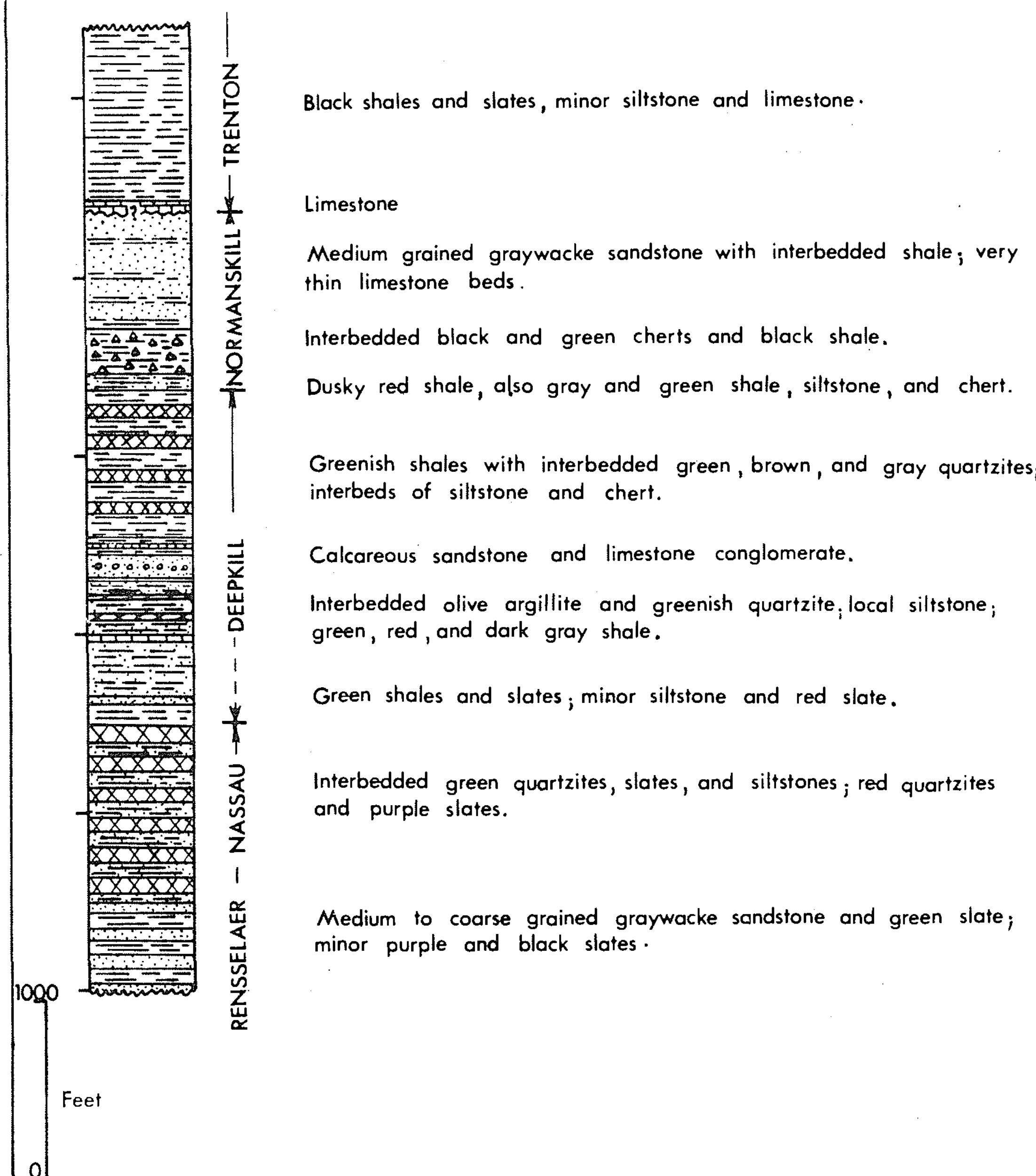
FIGURE 10 GENERALIZED STRATIGRAPHIC SECTION OF SOURCE AREA AS INFERRED FROM PETROGRAPHIC DATA (from Lucier, 1966, Fig. 23)





GEOLOGIC MAP
KAATERSKILL REGION

FIGURE 11 COMPOSITE STRATIGRAPHIC COLUMN OF ROCKS EAST OF STUDY AREA AND WEST OF TACONIC MOUNTAINS (from Lucier, 1966, Fig. 26)



as a function of progressive uplift and denudation of the source terrane (Fig. 11). The total minimum thickness of sediments (Normanskill-Nassau) eroded from the source area during this time was in excess of 4000 feet (Lucier, 1966, p. 81).

Preliminary study of the pebbles in the Slide Mountain Formation suggests previously deposited Catskill red beds (Plattekill?) served as a source for the detritus that later formed the younger conglomerates. Large pebbles of red sandstone identical with the red sandstones of the Plattekill Formation are a common constituent of the Slide Mountain. Apparently "cannibalism" of strata along the margin of the depositional basin occurred.

Summary

The sediments of the Catskill region reflects rhythmic braided stream and alluvial plain deposits. Periodic uplift of the Cambrian-Ordovician source during the Middle and Late Devonian produced highlands from which short torrential streams debouched (Fletcher, 1964a; Lucier, 1966). Coarse, immature detritus was deposited by coalescing streams on the upland part of the alluvial plain. The finer sediment fraction that was transported with the coarser had three alternatives: 1) being trapped in the interstices afforded by the pebbles and sand grains, 2) being swept beyond the alluvial plain into the marine part of the basin, or 3) being stranded on the lowland part of the alluvial plain as floodplain and interfluve deposits where oxidation and plant growth would proceed (Lucier, 1966, p. 86). The calcareous, shale-pebble breccia lenses commonly found in the sandstones possibly result from overbank steepening of the interfluve material. As erosion continued in the highlands stream flow would diminish and progressively finer detritus would be spread out over the previously deposited channel sands.

The classic picture of the so-called Catskill delta, in which a high range of mountains of Precambrian crystallines far to the east shed sediments into a constantly subsiding basin, becomes obsolete. Alternate periods of regression and transgression dominated sedimentary patterns during the Middle and Late Devonian. These alternations are concluded to be the result of tectonic activity in the faulted and folded flank zone of the geosyncline (Fig. 12; Fletcher, 1964a, p. 63) which occupied the present position of the Taconic Mountains. Increased tectonic activity, primarily in the form of folding and high-angle reverse faulting in the flank zone, brought to the surface rocks previously deposited in the marginal trough (Fig. 12). Thus, while Ordovician rocks were the dominant source for the lowermost Catskill sediments, "cannibalized" Devonian rocks from the rim of the marginal trough served as the source for the upper Catskill sediments.

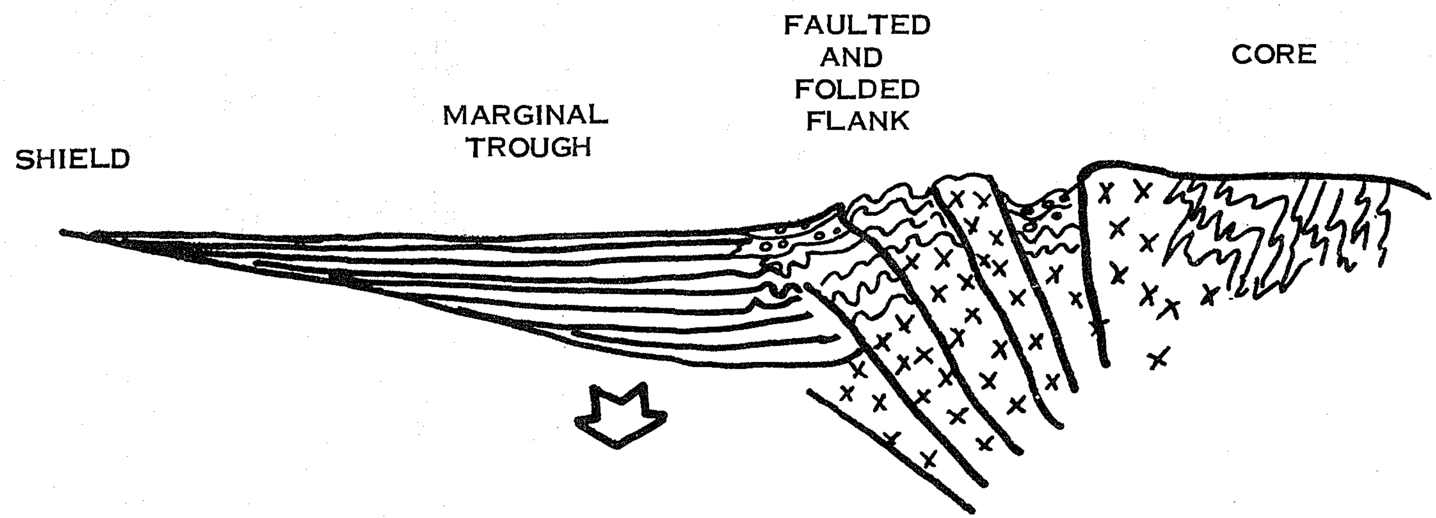


Figure 12 Interpretative reconstruction of tectonic framework of eastern New York in the Late Devonian.

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ROAD LOG TRIP C

Leader: Frank W. Fletcher — Guest Lecturer (Stop 3): Peter J. Buttner

MILEAGE

0.0 Holiday Inn, Newburgh (Field trip headquarters). Travel north on N.Y. Thruway.

42.0 Intersection of N.Y. Thruway exit and Rtes. N.Y. 32 and 212. Turn left (west).

42.3 Turn right (north) on Rte. N.Y. 32.

43.9 STOP 1 (15 minutes) Onondaga Limestone (Middle Devonian). This is primarily a stop for introduction to the basic Middle and Upper Devonian stratigraphic sequence of the Catskill Mountains region (see p. C1-C8). The Onondaga at this locality consists of very cherty, fossiliferous limestone. It dips toward 258° at 13° and forms a low escarpment.

An excellent panorama of the chief physiographic elements of the region can be observed from this location. The topographic depression directly west of the Onondaga escarpment is Bakoven Valley, which is underlain by the relatively soft black shales of the Bakoven Formation. The low Hoogeberg range west of Bakoven Valley is composed primarily of resistant siltstones of the Mount Marion Formation and is capped by the Ashokan Sandstone. The plain beyond the Hoogebergs is underlain at its most easterly part by the upper Ashokan Formation and at its westerly edge by red beds of the Plattekill Formation. Towering above all of these elements is the Catskill Front; and, beyond, the high peaks of the Catskills including Slide Mountain, Wittenberg Mountain, and Cornell Mountain, whose summits are composed of the Slide Mountain conglomerate (Fig. 4).

Continue north on Rte. N.Y. 32

48.0 Bear left on to Rte. N.Y. 32-A.

49.6 Cross Kaaterskill Creek.

50.0 Turn left on to Rte. N.Y. 23-A at traffic light in Palenville.

50.9 Cross Kaaterskill Creek again and begin climb up Catskill Front in Kaaterskill Clove.

53.8 STOP 2 (60 minutes) Manorkill and Gilboa Formations. Buses will allow field trip participants to disembark and then will drive to top of section. Participants will walk along right (north) side of highway to top of section. CAUTION: Road is narrow, so "cling" to side.

The upper part of Kaaterskill Creek can be seen approximately 0.2 miles northeast of this locality. This is the location of Prosser's classic example of stream piracy, where the headwaters of Schoharie Creek were captured by the much-steeper gradient Kaaterskill Creek.

Figure 13 describes the stratigraphic section of this stop. Many of the typical rock types and sedimentary structures of the lower Catskill facies can be observed here. Especially note-worthy are the fining-upward cycles discussed on page C1.

54.7 Top of section. Re-enter buses and continue west on Rte. N.Y. 23-A.

55.2 Turn right (north) in Haines Falls on to road to North Lake State Campsite.

55.3 Bear right.

58.3 Entrance to North Lake Campsite. Continue to North Lake beach parking area.

LUNCH (40 minutes)

*STOP 3 (90 minutes) Follow NYSGA trail markers along rim of Catskill Front to outcrop of the "Twilight Park Conglomerate." CAUTION: Watch your footing along the Front. Please remain at least five feet back from the edge of the cliff. NO SPECIMENS MAY BE TAKEN FROM WITHIN THE PARK BOUNDARIES.

Trail lies on strata of the lower Oneonta Formation. Note cross-bedding, excellent jointing and joint-controlled face of the Catskill Front. An excellent view of the Hudson Valley, the low Taconics, and, on very clear days, the Berkshires is available from the Front.

Return along trail to buses and return to field meeting headquarters.

*Guest Lecturer

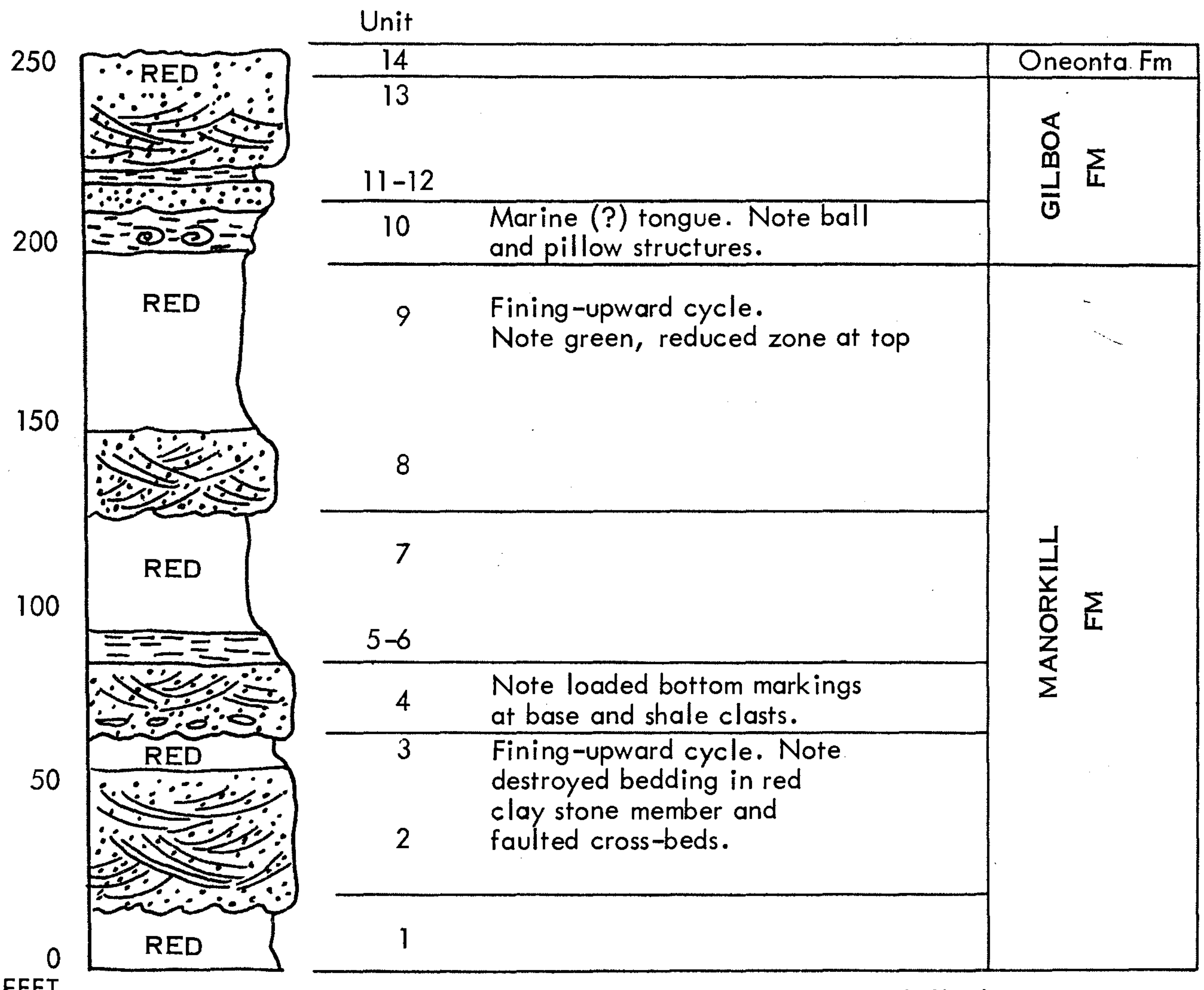


Figure 13 Stratigraphic section at Stop 2 in Kaaterskill Clove.

CONTINENTAL SEQUENCES IN THE PROXIMAL GENESEE GROUP (STOP 3, FIELD TRIP C)

PETER J.R. BUTTNER
Computing Center, University of Rochester

Introduction

Wedge-like in form and generally thinning to the south-west, the Devonian accumulation in New York displays a wide variety of sedimentary types and stratigraphic patterns. Proximally, in southeastern New York, about 10,000 feet of Devonian section has been preserved. The upper 6,000 feet of this sequence contains elements of the remnant sedimentary units of a set of Middle and Upper Devonian fluvial events. This collection of continental terranes has been discussed in some detail by Barrell (1913, 1914 a,b) and Chadwick (1933 a,b; 1936; 1944). It has become known as the Catskill Delta (Chadwick 1933 b). Included in this proximal continental sequence are rock units presently thought to be part of the Middle Devonian Hamilton Group, and the Genesee, Sonyea and the West Falls Groups of the Upper Devonian (Cooper and others, 1942; Rickard, 1964; Wolff, 1965, 1967).

Location

On the North Point Trail to North Mountain from North Lake in the SW1/4 of the NE1/4 of the Kaaterskill 7 1/2 minute quadrangle, Catskill State Park, Greene County, New York.

STRATIGRAPHIC SETTING AT STOP 3 (page C23)

The rock units encountered along the trail to Stop 3 are thought to be part of the proximal Genesee Group in southeastern New York. Several hundred feet below the elevation of the trail at Stop 3 the basal units of this rock body demonstrate a significant regressive overlap of dominantly near-shore and coastal plain sedimentary domains over the subjacent tidal estuary and lagoonal sedimentary domains observed in Kaaterskill Clove. The Genesee Group in this area is a domain of homogeneously rhythmic character (abcdeabcdeabcabcdabebcdabcde) and includes all the rock units to the top of the near mountains. It should be noted that this stratigraphic reckoning is founded on the physical character of this block of rock; the single characteristic of rhythmic patterning predominant. A succession of rock units have been assembled into an informal rock-stratigraphic unit in answer to a single terminal question: Do the units display some aspect of rhythmic fluvial sedimentation?

The stratigraphic plan followed is based on the recent summaries and modifications proposed by Rickard (1964), Wolff (1965, 1967) and, Friedman and Johnson (1966). Rickard has presented a bed rock map of the Devonian of New York together with a detailed chart of the stratigraphic design of the Devonian System in New York. Working within this scheme, Wolff, with the support of detailed field work in several key areas, has demonstrated a high-order rhythmic pattern of regressive and transgressive phases of deltaic sedimentation. At Stop 3 are some of the rock types which characterize the fluvial aspects of a regressive phase. The regional character and setting of the Middle and Upper Devonian of New York has been presented by Krumbein and Sloss (1963, p. 525, 535), Potter and Pettijohn (1963, p. 230) and, Friedman and Johnson (1966, p. 185-186).

THE NORTH POINT DOMAIN

The name North Point has been informally used to delimit the rock body thought to be the proximal Genesee Group in southeastern New York. Rhythmic continental sequences characterize this rock body (Buttner, 1965). Interpreted as the remnant elements of a sequence of coastal plain and upland fluvial deposits, a rhythmic sequence consists of a braided pattern of course conglomeratic channel-fill; a composite of point-bar, channel-fill, and overbank sandstones; and, overbank, mudflat, and general floodplain accumulations represented by siltstones and mudrocks (Buttner, 1966). Widespread lateral variability, rapid change in vertical sequence, steep-banked channels (some more than 30 feet in depth), and low to moderate thalweg sinuosity together with textural mapping support speculations about a coastal plain - upland sedimentary domain for the North Point.

Detailed mapping together with the analysis of data using various operations research methods and a computer have shown that rhythmic patterns may be found in: sediment color, texture, and petrology; transport directions; sedimentary structures and flow patterns; and lithosome geometries. Figure one shows the composite structure of a rhythmic sequence; the North Point contains at least 23 major rhythms of this type.

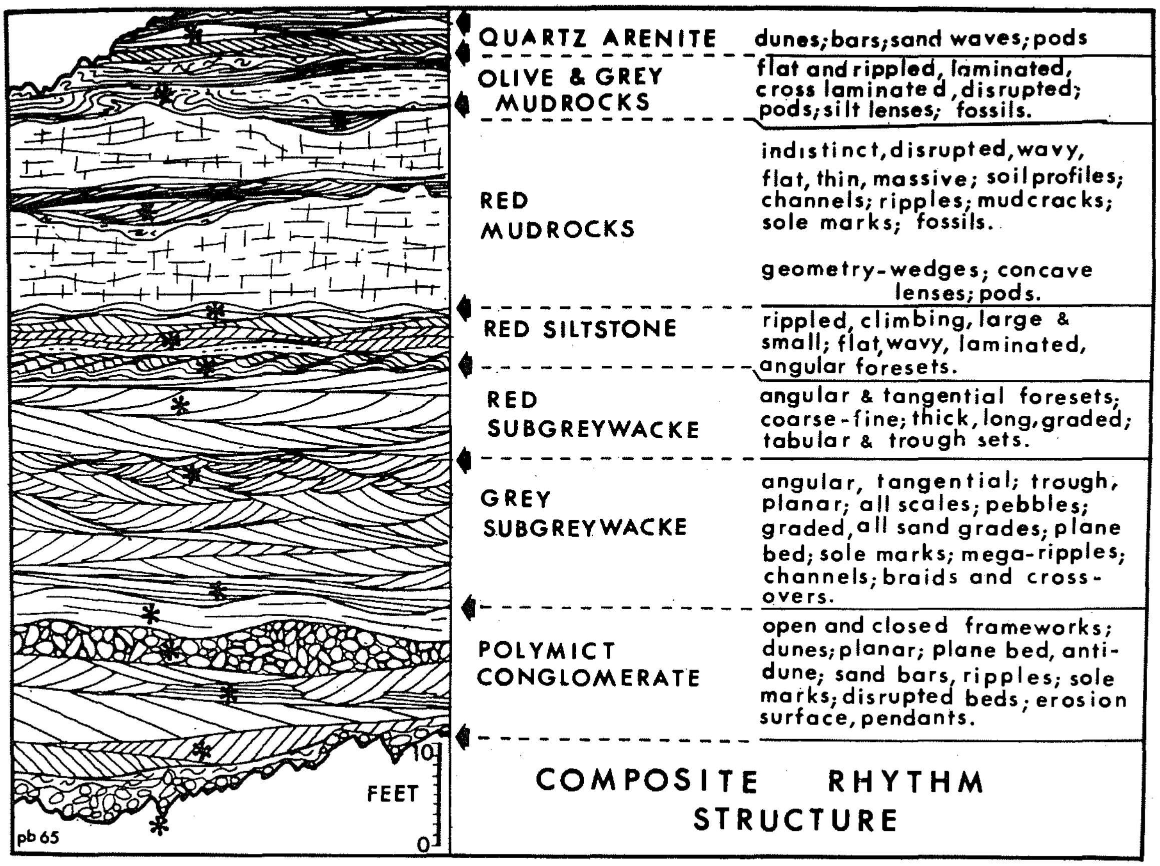


Figure 1. Composite Rhythm Structure in the North Point

As shown in Figure one, the rhythmic sequence is enclosed at base and top by erosion surfaces. A first impression of this structure is that there is a waxing and logarithmic waning of some fluvial event; what has been figured by several authors recently as a fining-upward cycle. Observation of more than one section and establishment of some geometric control reveals a much more complex arrangement of sedimentary associations. Adjacent sections, often as close as 5 meters, regularly display wide variation in rock types at the same interval. Figure two is an attempt to summarize some of the characteristics of a rhythmic sequence in the area of Stop 3. Here is represented a rhythmic sequence in the form of a symbolic analogue model in order to study some of its geometric aspects.

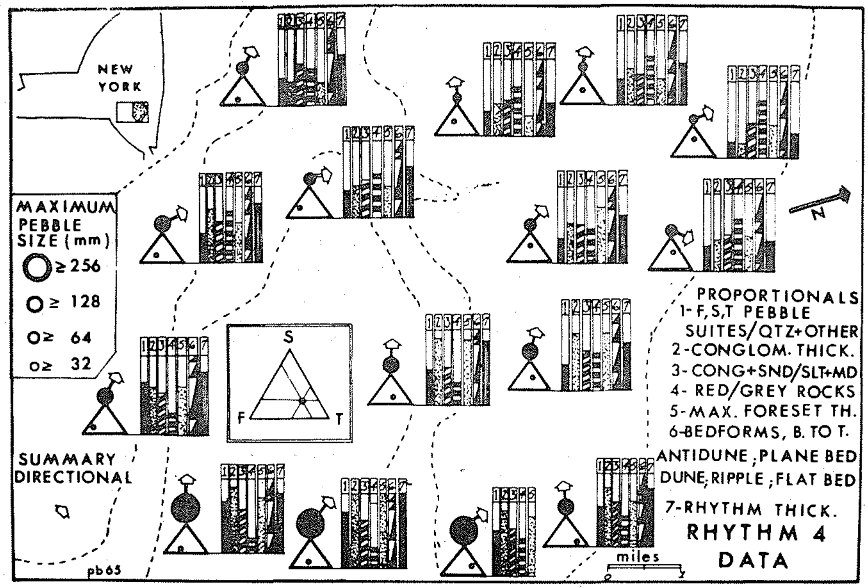


Figure 2. Symbolic Analogue Model of a Rhythmic Sequence

It is worthwhile to consider some of the types of formal models we might use to structure a rhythmic sequence. Figure three is presented to orient those unfamiliar with the concepts involved in model building and manipulation.

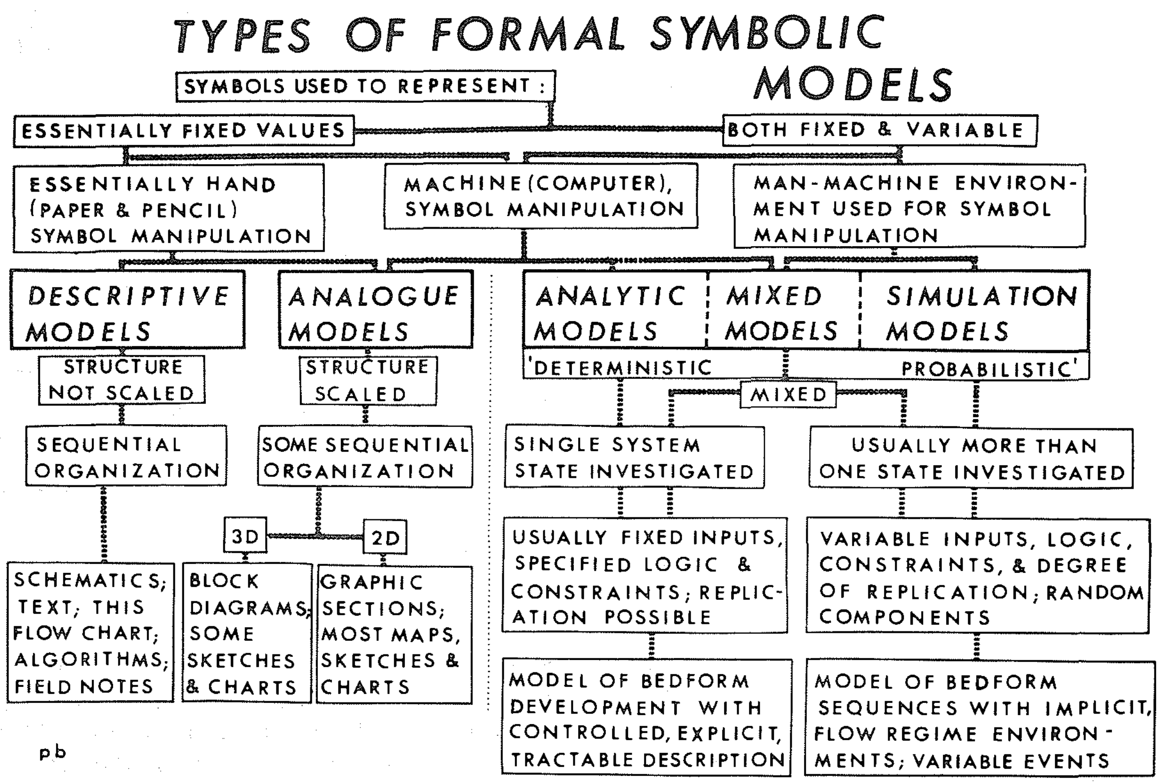
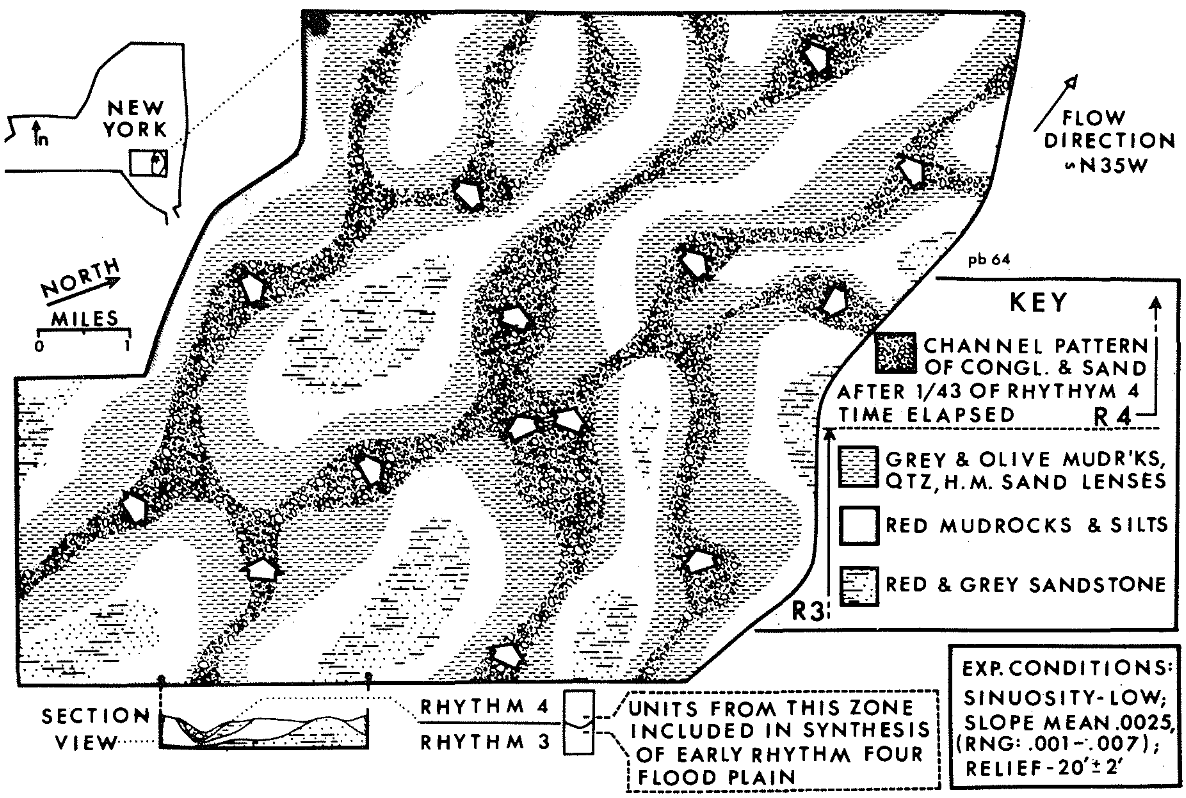


Figure Three. Types of Formal Symbolic Models

With the aid of a simulation model of the North Point domain I was able to experiment with various stratigraphic formats and sedimentologic designs and finally produced a configuration that not only showed close agreement with the field but also helped to explain the complex patterns in the field sections. This simulated rhythmic sequence is shown in Figure four. Represented is a paleogeographic surface of the coastal plain (in part of Kaaterskill Quadrangle) during an interval of time in the early stage of the development of a rhythmic sequence. As time progressed and the rhythm developed, the pattern changed. This is how a sequence of some 57 rhythms in the Catskill Complex was examined; looking in detail at their development over small increments of time. The picture figured here represents the graphic display of the synthesis of both the analogue and symbolic output from the computer. It is not possible to produce a single picture of this detail and complexity with even the most powerful computing system currently available.

It now becomes quite clear that the rhythmic sequences of the North Point were produced by the activities of a complex, braided fluvial system that was not far from a significant mountain source. A report on the sedimentology, dispersal, and petrology of the polymictic conglomerates in the North Point demonstrates the proximity and gross character of the source terranes (Buttner, manuscript in preparation). The main channels migrated laterally across the flood plain, while the main transport action was normal to the migration and downbasin (in the direction of least facies change). Migrations of the system produced the nested and imbricated patterns which contributed to the difficulties encountered in the correlation of adjacent sections.



SYNTHETIC FLOOD PLAIN & BRAIDED SYSTEM OF RHYTHM FOUR BY COMPUTER SIMULATION

Figure Four. Synthetic flood plain of the North Point at an early stage in the development of a rhythmic sequence.

SUMMARY REMARKS

The results of this six year study indicate that the lower Upper Devonian of southeastern New York was produced by a series of fluvial events. Moreover, the study has demonstrated that various computer techniques can be applied to help the field-oriented physical stratigrapher resolve complex stratigraphic problems where paleontological control is difficult to achieve. The use of these methods has been outlined by the author (Buttner, lecture notes in Briggs and Pollack, 1966), and the field geologist will soon be able to find consulting help at most computing installations.

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UPPER SILURIAN—LOWER DEVONIAN STRATIGRAPHIC SEQUENCE, WESTERN MID—HUDSON VALLEY REGION, KINGSTON VICINITY TO ACCORD, ULSTER COUNTY, NEW YORK

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Introduction

The remarks concerning the Upper Silurian and Lower Devonian stratigraphic units described in this paper largely pertain to strata within the Field Trip area (Fig. 1) extending in a belt from Accord (Stop 9) northeast to just beyond Kingston (Stops 1 and 2). The entire belt appears to be underlain with angular unconformity by a disrupted sequence of graywackes and shales to the northeast (Austin Glen affinity) and shales and siltstones to the southwest (Snake Hill affinity). The relations of these two lithologic groups in this area are not clear but it does seem that both were somewhat uplifted and folded (if not faulted) during the Taconian Orogeny; by latest Middle Silurian (?) the Ordovician sediments and structures were eroded to a surface of seemingly low relief or uniform slope. Subsequently a sequence of conglomerate (Shawangunk), shale (High Falls), sandstone (Binnewater) and carbonate (Rosendale-Wilbur) was deposited on the erosion surface in an apparent, general progression to the northeast.

From Rosendale-Wilbur times through the remaining Late Silurian and Early Devonian the region was generally covered by marine waters, although intertidal and supratidal conditions existed intermittently on a local to regional scale. The Late Silurian and Early Devonian strata are relatively uniform in lithology and thickness throughout the area but some local and regional differences in depositional environments are evidenced within the Rondout, Thacher, Connelly and perhaps other formations. Apparent throughout the Rondout-Lower Devonian sequence is a more or less rhythmic alternation of variously interrelated, high energy-low energy, clay-carbonate, "shallow water" - "deep water", marine environments of deposition.

UPPER MIDDLE-LOWER UPPER SILURIAN

SHAWANGUNK CONGLOMERATE: Shawangunk Grit, Mather, 1840, p. 246-250; Stops 5, 7, 8, 10.

Lithology: Generally light-colored, well-indurated conglomerate of well-rounded quartz pebbles with lesser amounts of quartz arenite and occasional thin red to green shales. Bedding generally thick to massive with cross-bedding common. Typically cliff-forming, capping the Shawangunk Mountain cuesta.

Distribution: Extensively exposed in Shawangunk Mountains in southwest part of area (Fig. 1). Absence north of Stops 5 (Maple Hill) and 7 (Williams Lake) apparently due to non-deposition.

Thickness: Increases southwestward from zero to about 300 feet (Berkey, 1911, p.136).

Lower Contact: In angular unconformity with underlying Ordovician shales and siltstones of Snake Hill (?) affinity (Stop 5).

Upper Contact: Distinct and apparently conformable with overlying High Falls Shale or gradational or interbedded through less than one foot (Stops 5, 8, 10). Uppermost foot or so of conglomerate atypically dark in color in High Falls - Rosendale area.

Fossils: None observed or reported in area.

Age: Middle Silurian (Fisher, 1960) but possibly late Middle Silurian if gradational to Late Silurian High Falls Shale (Fisher, 1960).

Members: Not subdivided in area but inspection of exposures along Shawangunk Mountain cuesta suggests two or three members may be recognizable.

Environment: Possibly marine, pebble and sand beach and/or near-shore conditions.

UPPER SILURIAN

HIGH FALLS SHALES: High Falls Shales, Hartnagel, 1905, p. 345; Stops 5-8, 10.

Lithology: Red to olive to green calcareous to non-calcareous shales, silty shales and mudstones, with occasional thin argillaceous limestones and dolostones. Occasionally ripple-marked or with desiccation cracks. Generally thin-bedded to finely laminated but bedding seemingly massive on occasion or obscured by foliation. Typical red coloration tends to be more pronounced toward the base to the southwest. Generally slope-forming.

Distribution: Exposures from Fourth Lake (Stop 6) and Maple Hill (Stop 5) south to Accord. Apparently absent to the north (Stop 3) due to non-deposition.

Thickness: Increases southwestward from zero to over 80 feet at High Falls.

Lower Contact: Other than with Shawangunk Conglomerate (which see); angular unconformity with Ordovician shales of Snake Hill aspect inferred but not observed. (Stop 6).

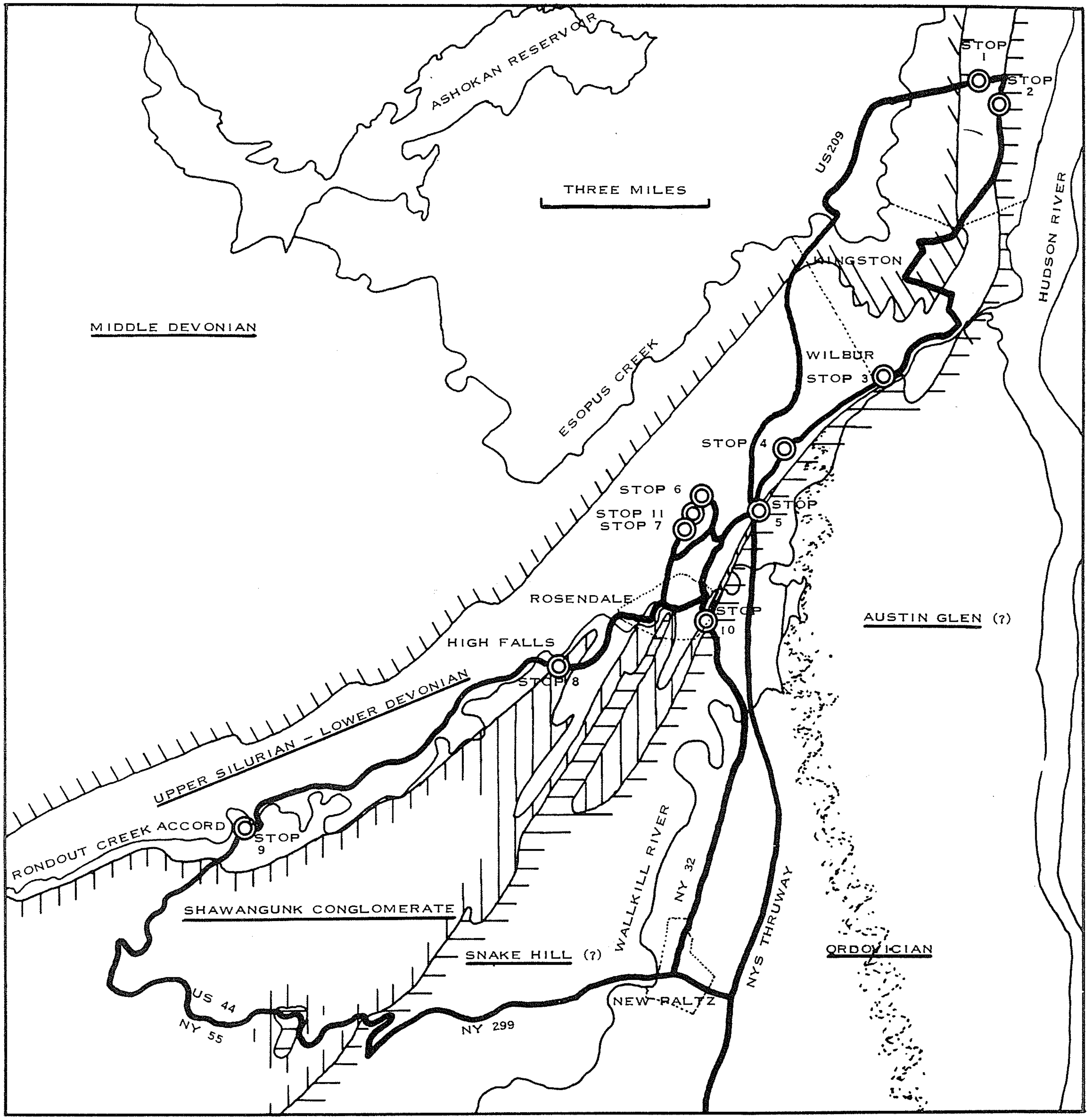
Upper Contact: Distinct to gradational to interbedded through several feet with overlying Binnewater Sandstone. (Stops 6, 10).

Fossils: None reported or observed in area except for occasional vermiform trails and burrows.

Age: Late Silurian, Canastotan, (Fisher, 1960).

Members: None recognised in the area but some thin carbonate units may prove useful as marker beds from High Falls to Accord.

Environment: Apparently marine, shallow water to intertidal to occasionally supratidal with oxidizing conditions or red-bed source.



SKETCH MAP
FIELD TRIPS D AND H

Fig. 1

BINNEWATER SANDSTONE: Binnewater quartzite, Hartnagel, 1905, p. 346; Stops 3,5,6,7,10,11.

Lithology: Light grey to brownish to greenish, occasionally well-indurated quartz arenite; somewhat dolomitic with occasional thin beds of shale, shale-carbonate and carbonate-shale rock increasing to the southwest. Generally thin-to medium-bedded; commonly cross-bedded to cross-laminated with ripple marks and with occasional desiccation cracks, slightly conglomeratic with shale pebbles in base when overlying Ordovician surface; cliff- to slope-forming.

Distribution: Exposures common from Wilbur (Stop 3) southwest to High Falls. Apparently absent north of Wilbur due to non-deposition (Stop 2).

Thickness: Increasing southwestward from zero north of Wilbur to 35 feet at High Falls.

Lower Contact: Other than with High Falls Shale (which see); in angular unconformity with Ordovician graywackes of Austin Glen aspect at Wilbur (Stop 3) and on Fly Mountain.

Upper Contact: In disconformable contact with overlying Rosendale Member of Rondout Formation from location 9 (Fig. 2b) between High Falls and Rosendale northwest to Wilbur (Stops 3,6,7,10), (Hoar and Bowen, 1967, p. 3). Contact at High Falls apparently conformable.

Fossils: Seemingly unfossiliferous except for uppermost three feet where fossils including stromatoporoids and occasional solitary rugose corals have been found (Hoar and Bowen, 1967, p.3) (Stops 10,11).

Age: Late Silurian, Murderian (part) (Fisher, 1960).

Members: None presently recognised in the area.

Correlatives: In the Accord area (Stop 9); Bossardville ? Formation (Hoar and Bowen, 1967, p. 3) equals Accord Shale of Fisher (1960); finely laminated, light grey-green, argillaceous dolomite and dolomitic shale, with possible desiccation cracks or fragments (similar to shale-carbonate beds in upper part of Binnewater Sandstone at High Falls and elsewhere). Physical correlation not yet established but relation inferred from equivalent stratigraphic position and lithology. Total thickness of Accord sequence unknown. Contact with overlying Rosendale Member conformable.

Environment: Best summarized by Hoar and Bowen (1967, p. 10). Near shore supratidal, less uniform conditions of sedimentation (northeast); grading to offshore generally more uniform, subtidal conditions (southwest).

RONDOUT FORMATION: Rondout waterlime, Clarke and Schuchert, 1899, p. 874-878; (here used in the sense of Rickard, 1962, p. 30); Stops 2, 3, 6, 7, 9, 11.

Lithology: Predominantly dolostones and limestones; further discussed under component members.

Distribution: Widely distributed from north of Kingston (Stop 2) to Accord (Stop 9).

Thickness: Generally increasing to the southwest; about 30 feet north of Kingston (Stop 2) to about 50 feet estimated in the vicinity of Accord (Stop 9).

Lower and Upper Contacts: See lower contact and upper contact of Rosendale-Wilbur Members and Whiteport member respectively.

Fossils: Refer to notes on component members.

Age: Late Silurian, Murderian (part) (Fisher, 1960).

Members: From bottom to top: Wilbur, Rosendale, Glasco and Whiteport Members (which see).

Environment: Marine, variously supra- to subtidal, biostromal, agitated to quiet water.

See remarks on component members.

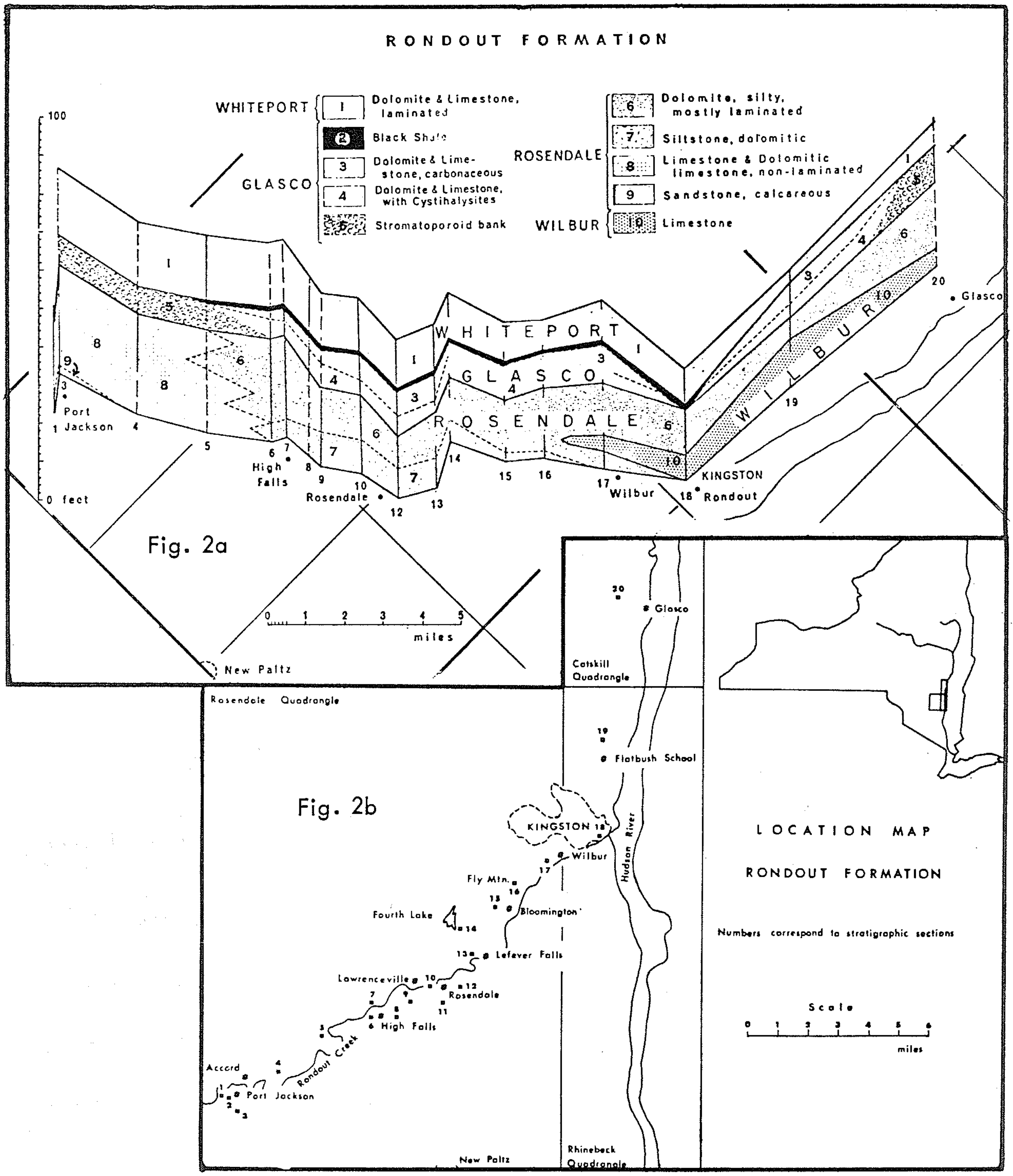


Fig. 2a Stratigraphic relations of the Rondout Formation members.

Fig. 2b Location map.

(Both figures adapted from Hoar and Bowen, 1967, text-figs. 1, 2; locations 3 (Fig. 2a), 11 (Fig. 2b), 14, 17 and 19 correspond to Stops 10, 9, 6, 3 and 2 respectively.)

WILBUR LIMESTONE: Wilbur limestone, Hartnagel, 1903, p. 1142-1152; Stops 2, 3;

Lithology: Dark colored, weathering light-gray, fine- to coarse-grained, occasionally silty limestone; slightly to very fossiliferous; thin- to medium-bedded; with occasional thin shaly partings and occasional cross-laminations; cliff-forming on occasion.

Distribution: Exposures from vicinity of NY 32 (Stop 2) south to Wilbur (Stop 3), (Fig. 2a).

Thickness: Four feet (Stop 3) to 12 feet (Stop 2). Apparently absent south of Stop 3 due to non-deposition.

Upper Contact: Conformable and gradational in places to overlying Rosendale Dolomite.

Lower Contact: Conformable and gradational where intertonguing with Rosendale Member at Wilbur (Stop 3); in angular unconformity with Ordovician graywackes to the north (Stop 2).

Fossils: Diverse fauna including brachiopods, gastropods, bryozoa, tabulate and reguse corals, stromatoporoids, occasional trilobites and pelmatozoan fragments.

Age: As for Rondout Formation.

Environment: Marine; biostromal; subtidal to occasionally intertidal; high energy regions with marginal low energy areas.

ROSENDALE DOLOMITE: Rosendale ls., Hall, 1893, p. 159; (Here used in the sense of Rickard, 1962, p. 35; and Hoar and Bowen, 1967 p. 4-8); Stops 2, 3, 6, 7, 9.

Lithology: Four distinctive lithologies (Fig. 2a); a) primarily silty, laminated, poorly fossiliferous dolomite; b) laminated to thin-bedded, occasionally fossiliferous, dolomitic siltstone; c) argillaceous to silty, partly dolomitic, thin- to medium-bedded fossiliferous limestone; d) cross-bedded, fossiliferous, calcareous quartz arenite. Dolomitic and silty facies to the northeast (Stops 2, 3, 6, 7) grading to calcareous and basal sand facies to the southwest (Stop 9).

Distribution: Frequently exposed throughout the field trip area from Stop 2 in the northeast to Stop 9 in the southwest.

Thickness: Generally increasing in thickness to the southwest from about six feet at Stop 2 to about 27 feet near Stop 9.

Upper Contact: Conformable and, on occasion, gradational to the overlying Glasco Limestone. Determined by the absence of Cystilhalycites according to Hoar and Bowen (1967, p. 9).

Lower Contact: Refer to upper contacts of Binnewater Sandstone and Wilbur Limestone.

Fossils: Generally without fossils in dolomitic and silty facies to northeast, but with increasing fossil content in calcareous facies to southwest. Fauna includes brachiopods, tabulate and rugose corals, stromatoporoids (Stop 9) and pelmatozoan fragments.

Age: As for Rondout Formation.

Environment: Marine, high to low energy, generally subtidal, with agitation increasing to the southwest.

GLASCO LIMESTONE: Glasco limestone, Chadwick, 1944, p. 44-55; Stops 2, 6, 7, 9

Lithology: Four distinctive lithologies (Fig. 2a): a) medium-grained, highly fossiliferous argillaceous, thin- to medium-bedded, limestone and dolomite; bearing *Cystihalycites*; b) biostromal limestone; c) laminated to medium-bedded, argillaceous and carbonaceous, limestone and dolomite; d) black, calcareous to dolomitic, fossiliferous shale, topmost member. The basal unit a) grades southwest into b). Cliff- to slope-forming.

Distribution: Widely exposed from Stop 2 in the northeast to Stop 9 in the southwest.

Thickness: Generally thickening from two feet at Kingston to 10 feet, more or less, to the north and southwest (Fig. 2a).

Upper Contact: Conformable and distinct to possibly gradational locally with overlying Whiteport Dolomite.

Fossils: Diverse fauna including stromatoporoids, tabulate and rugose corals, bryozoa, brachiopods, trilobites, ostracods, and pelmatozoan fragments. Stromatoporoids abundant in biostromal facies; *Cystihalycites* common in non-biostromal lower part of member.

Age: As for Rondout Formation.

Environment: Marine, biostromal to "off-reef", high to low energy. Biostromal portion to the southwest associated with underlying high-energy Rosendale calcareous facies; non-biostromal or "off-reef" portion to the northeast associated with underlying low energy dolomitic and silty facies of Rosendale member. (Hoar and Bowen, 1967, p. 11).

LOWER DEVONIAN?

WHITEPORT DOLOMITE: Whiteport member, Rickard, 1962, p. 36; Stops 2, 6 (type section), 7.

Lithology: Medium to dark gray, buff-weathering, fine-grained, laminated, generally unfossiliferous, argillaceous dolomites, calcareous dolomites, and dolomitic limestones with occasional desiccation cracks and ripple marks.

Distribution: Scattered exposures from north of Kingston (Stop 2) southwest to vicinity of Stop 9.

Thickness: Generally thickening southwest from about four feet at Stop 2 to an estimated 16 feet in the vicinity of Accord.

Upper Contact: Conformable with overlying Thacher Limestone and commonly marked by a thin dark calcareous shaly interval in the base of the Thacher (Stop. 2). On occasion contact apparently gradational (Stop 6?).

Fossils: Generally unfossiliferous but occasional brachiopods, ostracods and stromatoporoids are known.

Age: Considered Lowermost Helderbergian (Rickard, 1962, p. 106). A precise Silurian or Devonian assignment is tenuous at present.

Environment: Marine, largely intertidal to supratidal to shallow subtidal.

LOWER DEVONIAN

THACHER LIMESTONE: Thacher Limestone Member of Manlium Formation, Rickard, 1962, p. 43; Stops 1, 2, 6, 11.

Lithology: Mixed carbonate lithology: a) dark gray, medium-weathering, fine-grained, thin-bedded, occasionally fossiliferous limestones with thin shaly partings; the inch or ribbon beds of some authors; predominant near base of member. b) argillaceous, silty, siliceous, laminated, rarely fossiliferous, fine-grained dolomites of the Whiteport Member; predominant in lower part. c) dark, medium-weathering, thick- to thin- and regularly- to irregularly-bedded, slightly to very fossiliferous limestone with rubbly to massive weathering; predominant in upper part of the member. d) obscurely-bedded, stromatoporoidal, biostromal limestone; predominant near top of the member.

General Distribution: Commonly exposed in the Lower Devonian portion of the trip area from Stop 1 in the northeast to the vicinity of Stop 9 in the southwest.

Thickness: Relatively uniform throughout the region; from 52 feet (Stop 2) to 46 feet in the vicinity of Accord; most variation of thickness confined to upper part of member (Pedersen, 1966a, 1966b).

Upper Contact: Locally variable, from distinct to gradational to interbedded to disconformable with overlying Ravena limestone.

Fossils: Fauna varied, including brachiopods, stromatoporoids, gastropods, ostracods, algae, tentaculitids, etc.

Sub-units: In the map area traceable units have been demonstrated in lower part of member (Pedersen, 1966a, 1966b), but the upper part is more variable in lithology.

Age: Lower Helderbergian. (Rickard, 1964).

Environment: Marine, quite variable; biostromal and high energy to "off-reef" and low energy, supratidal to intertidal to subtidal.

RAVENA LIMESTONE: Ravena Limestone of Coeymans Formation, Rickard, 1962, p. 65); Stops 1, 2, 11.

Lithology: Light colored, light- to white-weathering, massive to thin-bedded, iregularly-bedded or wavey-bedded, biofragmental, fine-grained limestone with occasional cross-bedding. Cliff- to slope-forming.

General Distribution: Commonly associated with Thacher Limestone, from Stop 1 in the northeast to the vicinity of Accord (southwest).

Thickness: Relatively uniform from 17 feet at Stop 1 to 20 feet near Rosendale to 18 feet near Accord.

Upper Contact: Gradational through one foot or so with overlying Hannacroix Member of Kalkberg Limestone; usually picked at appearance of first chert nodules.

Fossils: Pelmatozoan debris and brachiopods common; lesser numbers of tabulate corals, massive bryozoa, trilobites, ostracods and cephalopods; presence of *Gypidula coeymanensis* useful in determining the Thacher-Ravena contact.

Age: Lower Helderbergian in the field trip area (Rickard, 1964).

Environment: Marine, uniform, high energy, subtidal within wave base, not biostromal.

KALKBERG LIMESTONE: Kalkberg Limestone, Chadwick, 1908, p. 346-348; (here used in the sense of Rickard, 1962, p. 79); Stops 1, 11.

Lithology: Four major lithologic subdivisions (Stop 1) (Dun *in* Dun and Rickard, 1961, p. C9, C11) in ascending order: (a) medium gray, cherty, fine-grained, fossiliferous thin- to medium-bedded, ledge-forming limestone; (b) light gray, fine-grained, thin- to thick-bedded, slope-forming, argillaceous and siliceous limestone with numberous irregular or wavy shaly partings; (c) light gray, thin-bedded, slope-forming, fine-grained, argillaceous and siliceous, fossiliferous limestone with numerous interbedded, calcareous shale layers and with a one to two foot bed of dark shale at base; (d) gray, thin- to medium-bedded, slope-forming, fine-grained, argillaceous and siliceous limestone with a characteristic pitted weathered surface.

General Distribution: Recognized the extent of the field trip area but rarely completely exposed; unit (a) above is best exposed and extends from north of Kingston (Stop 1) southwest to the vicinity of Accord.

Thickness: About 70 feet north of Kingston (Stop 1); southwestward thicknesses not as certain because upper part of formation may be included in New Scotland Formation by many workers.

Upper Contact: Based on change from argillaceous and siliceous limestone to overlying calcareous mudstone and siltstone of New Scotland Formation. (Dun *in* Dun and Rickard, 1961, p. C11).

Fossils: Variable fauna, partly reflected by changes in lithology; includes brachiopods, pelmatozoan fragments, bryozoa, trilobites, ostracods, and solitary tetracorals. Notable brachiopods are *Gypidula coeymanensis*, *Dicoelosia* (*Bilobites*) *varicus*, and *Koslowskielina* ("*Spirifer*") *perlaminellosa*.

Members: Two subdivided members recognized by Dun (*in* Dun and Rickard, 1961) based on lithologies listed above; from bottom to top: Hannacroix Member, lower(a), upper(b); Broncks Lake Member, lower(c), upper(d).

Age: Early Helderbergian (Rickard, 1964).

Environment: Marine, generally uniform, moderate to low energy, generally subtidal, generally above or near wave base.

NEW SCOTLAND FORMATION: New Scotland beds, New Scotland limestone, Clarke and Schuchert, 1899, p. 874-878; (here used in the sense of Rickard, 1962, p.85); Stop 1.

Lithology: Primarily an alternating sequence of very fine-grained calcareous siltstones and mudstones at the base grading upward into argillaceous and silty limestones; generally thin-bedded but massive weathering on occasion and leached out in more calcareous portions or pods.

General Distribution: Known to occur the length of the field trip area but better exposed northeast from High Falls.

Thickness: Estimated about 100 feet north of Kingston (Stop 1); to the southwest, thicknesses often questionable due to transitional nature of upper contact and by frequent inclusion of upper part of Kalkberg Formation by many workers.

Upper Contact: Gradational, interbedded; interbeds of New Scotland and overlying Becraft lithology; Becraft-like beds thickening upward; choice of contact arbitrary.

Fossils: Highly fossiliferous, with brachiopods, pelecypods, gastropods, trilobites, ostracods, bryozoa. Notable brachiopods are *Eospirifer macropleurus* and *Kozlowskielina perlamellosa*.

Age: Middle Helderbergian (Rickard, 1964).

Environment: Marine, uniform, subtidal, generally near or below wave base.

BECRAFT LIMESTONE: Becraft limestone, Darton, 1894b, p. 406-407, (suggested by Hall, 1893, p. 9-13); Stop 1.

Lithology: Light gray, coarse-grained, biofragmental, cliff-forming, massive-weathering pelmatozoan limestone with thin to thick irregular bedding increasing upward in thickness and irregularity.

General Distribution: Exposure known from vicinity of Accord northeast to Stop 1, but most outcrops of formation are northeast of High Falls.

Thickness: Estimated thickness of 55 feet on NY 32 south of Stop 2. Thicknesses either variable or uncertain because of gradational nature of lower contact and possible inclusion of Alsen Limestone. In a southwesterly progressing sequence the following thicknesses are known or reported: South of Stop 2 on Highway NY 32 - 55 feet estimated; Kingston area, (Darton, 1894b; Van Ingen and Clark, 1903) - 35 - 40 feet; near Whiteport, (Darton, 1894b) - 30 feet; between High Falls and Accord (Berkey, 1911) - 75 feet.

Upper Contact: Conformable and, in the field trip area, more or less distinct or gradational through a foot into overlying Alsen Limestone.

Fossils: Predominantly pelmatozoan fragments but with brachiopods, gastropods and trilobites. Notable are "*Spirifer*" *concinnus* and the thimble-like crinoid "holdfast" *Aspidocrinus scutelliformis*.

Age: Late Helderbergian (Rickard, 1964).

Environment: Marine, uniform, high energy, subtidal, well above wave base, "crinoid-bank".

ALSEN LIMESTONE: Alsen cherty limestone, Grabau, 1919, p. 468-470; Stop 1.

Lithology: Dark gray, fine-grained, thin- to medium-bedded, argillaceous, slope-forming limestone; only slightly cherty (from Kingston southwest).

General Distribution: Recognized in field trip area from north of Kingston (Stop 1) southwest to Rosendale; probably present in Accord area but not recorded.

Thickness: Twenty feet measured north of Kingston (Stop 1); similar thickness reported at East Kingston (Dun and Rickard, 1961, p. C14).

Upper Contact: Conformable distinct or gradational over a short interval with overlying Port Ewen Formation.

Fossils: Fauna includes brachiopods, bryozoa and corals. Notable are the bryozoan *Monotrypa tabulata* and "*Spirifer*" *concinnus*.

Age: Late Helderbergian (Rickard, 1964).

Environment: Marine, uniform, low energy, subtidal, at or near wave base.

PORT EWEN FORMATION: Port Ewen limestone, Clarke, 1903, (N.Y. State Mus. Handbook, 19, p. 21); (used in the sense of Rickard, 1962, p. 91-92); Stop 1, 4.

Lithology: Dark gray, fine-grained, thin- to medium-bedded, sparsely fossiliferous, highly argillaceous, limestones and calcareous mudstones with numerous ellipsoidal non-argillaceous limestone nodules (not concretions) throughout and with occasional heavy chert developments near top of section; weathered surface typically with large hollowed-out pits representing dissolved nodules; generally slope-forming.

General Distribution: Known in the field trip area from north of Kingston (Stop 1) southwest to the High Falls — Rosendale region; probably present in the Accord area as well.

Thickness: Estimated thickness north of Kingston (Stop 1) is between 70 and 80 feet. Apparently thickening southwest to possible 125 feet (Darton, 1894b) (exact location not known).

Upper Contact: Apparently disconformable locally and in angular unconformity regionally with overlying Connelly Formation or (where absent) with Glenerie Formation.

Fossils: Fossils rare although trilobites observed in section in limestone nodules; occasional brachiopods and the feeding-burrow *Zoophycus* cf. *Z. cauda-galli* noted in natural section in the upper half of the formation.

Age: Latest Helderbergian in field trip area (Rickard, 1964).

Environment: Marine, uniform, low energy, mostly below wave base; slightly reducing conditions.

CONNELLY FORMATION: Connelly conglomerate, Chadwick, 1908, p. 346-348; Stop 4.

Lithology: Mixed lithology; interbedded pebble conglomerates, quartz arenites, black shales, chert beds and all intergradations; thin- to thick-bedded; usually not well-exposed.

General Distribution: Not well-defined; apparently absent at Stop 1 but present (2-3 feet) a mile or so south on NY 32. More or less continuous south and southwestward through Connelly, Bloomington, and Maple Hill to Rosendale. Apparently absent north of High Falls but possibly reported by Darton (1894b, p. 460-461) northwest or west of Accord.

Thickness: Generally up to 18 or 20 feet; 19 feet estimated for Stop 4. Absence either due to non-deposition, pre-Glenerie erosion or lateral gradation to different lithology.

Upper Contact: Apparently locally conformable, disconformable or gradational with overlying Glenerie Formation.

Fossils: Generally unfossiliferous but some brachiopods of Glenerie aspect noted in upper sandstones (Stop 4).

Age: Middle Deerparkian (Rickard, 1964).

Environment: Marine (at least partly), variable, high to low energy, subtidal to supratidal?, above wave base.

GLENERIE FORMATION: Glenerie limestone, Chadwick, 1908, p. 346-348; Stop 1, 4.

Lithology: Mixed lithology: interbedded, siliceous and fossiliferous limestones, chert beds, and shales; thin- to medium-bedded.

General Distribution: Apparently present throughout the field trip area but only well-exposed to the northeast.

Thickness: About 50 feet reported from the East Kingston area by Van Ingen and Clark (1903, p. 1199); thickening southwestward to 80 feet near Whiteport (ibid.).

Upper Contact: Probably gradational with the overlying Esopus Formation through a small interval.

Fossils: Brachiopods and occasional trilobites. Costispirifer arenosus and Acrospirifer murchisoni are among the more common brachiopods.

Age: Late Deerparkian (Rickard, 1964).

Environment: Marine, variable, high to low energy, subtidal, above wave base.

ESOPUS FORMATION: Esopus shales, Darton, 1894b, p. 209-210; Stop 1.

Lithology: Dark to black, soft-weathering, non-calcareous argillaceous siltstones and silty shales.

General Distribution: Widely distributed along the western side of the Upper Silurian — Lower Devonian belt from north of Kingston (Stop 1) to the Accord area.

Thickness: About 200 feet in the Kingston area and probably thickening considerably to the southwest (inferred from Berkey, 1911, p. 126).

Upper Contact: Apparently conformable with the Carlisle Center Member of the Schoharie Formation and distinct; locally disconformable (Johnsen and Southard, 1962, p. A11).

Fossils: Relatively unfossiliferous except for occasional brachiopods and typically abundant feeding-burrows of Zoophycus cauda-galli.

Age: Early Onesquethawian (Rickard, 1964).

Environment: Marine, uniform, low energy, mostly below wave base; reducing conditions.

SCHOHARIE FORMATION: Schoharie layers, Vanuxem, 1840, p. 378; (used here in the sense of Johnsen and Southard, 1962); Stop 1.

Lithology: Three primary lithologic sequences from bottom to top: (a) interbedded and intergradational calcareous mudstone and muddy limestone; thin- to thick-bedded; with a distinctive banded appearance; bedding partially disrupted by burrowing activity; with a distinctive two to three foot siliceous black bed about one third above the base. (b) Interbedded and intergradational muddy limestone and calcareous mudstone with distinctive ellipsoidal lime nodules (not concretions); banding present as in (a) but less distinctive. (c) interbedded limestones and very calcareous mudstones; much more fossiliferous than (a) or (b) north of Kingston (Stop 1).

General Distribution: Occuring all along the western margin of the Upper Silurian - Lower Devonian belt from Kingston southwest to Accord but best exposed to the northeast.

Thickness: Thickening to the southwest from about 180 feet north of Kingston (Stop 1) to about 215 feet west of the Accord area (Johnsen and Southard, 1962).

Upper Contact: Conformable and gradational with the overlying Onondaga Limestone over an interval of one foot or so.

Fossils: Faunal diversity increasing upward through the section; includes brachiopods, trilobites, solitary tetracorals, bryozoa, diverse types of burrows including *Zoophycus cauda-galli*, gastropods, etc.

Members: Three members recognized in Kingston area (Johnsen and Southard, 1964) corresponding to lithologies above - from bottom to top; Carlisle Center Member (a), Aquetuck Member (b) and Saugerties Member (c); distinction between upper two members lost to the southwest.

Age: Early to Middle Onesquethawian (Rickard, 1964).

Environment: Marine, uniform, low energy, near or below wave base.

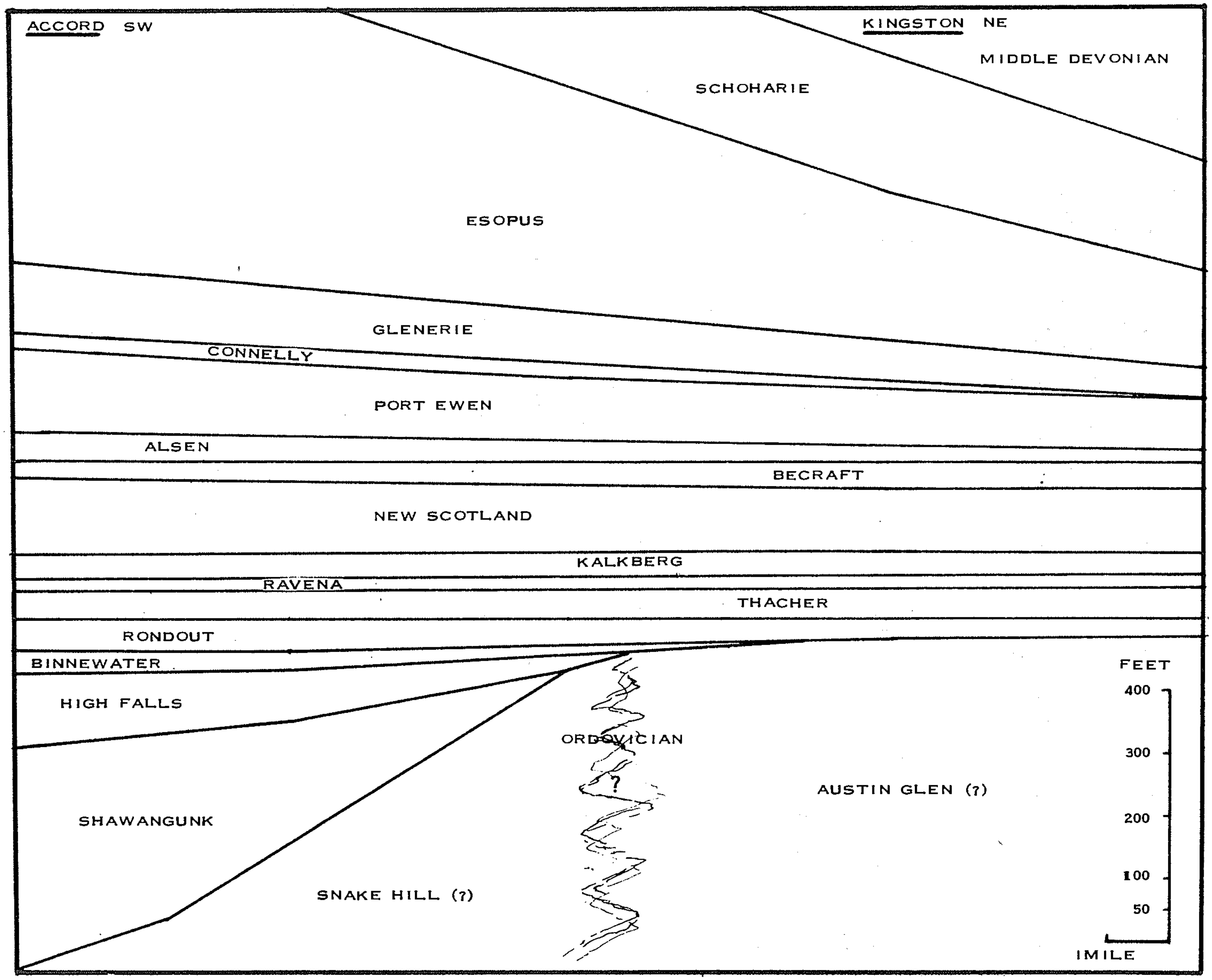


Fig. 3 Stratigraphic relations of Upper Silurian — Lower Devonian Formations, Accord to Kingston, New York (base line top of Rondout).

ROAD LOG FIELD TRIP D

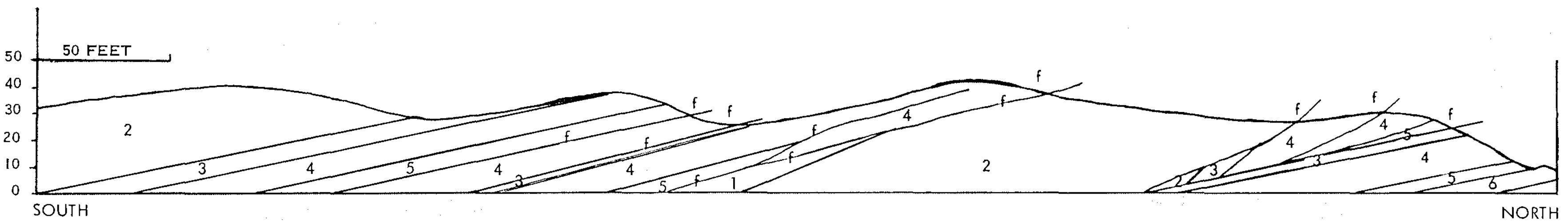
Co-leaders: Russell H. Waines and Florence Grosvenor Hoar

TOTAL MILES	Miles Between Points	Remarks
0.0	0.0	Holiday Inn parking lot. Exit, turning left (east) onto NY 17K. Continue 0.2 miles past traffic light (at intersection of NY 17K and Union Avenue). Turn left toward NYS (New York State) Thruway as indicated by sign.
1.4	1.4	Toll Booth, NYS Thruway Interchange 17 (Newburgh). Proceed north (right) onto Thruway toward Albany. Between Newburgh and New Paltz occur occasional road cuts in Ordovician (Martinsburg-Snake Hill (?)) slates and siltstones. Note the generally progressive decrease in degree of foliation of the beds northward.
17.5	16.1	NY 299 overpass near NYS Thruway Interchange 18 (New Paltz). North of New Paltz the degree of foliation in several extensive road cuts in the Ordovician shales is much less pronounced than further south. A fauna found in Ordovician beds north of New Paltz shows affinities with that of the Snake Hill Shale (Late middle Ordovician).
23.4	5.9	Wallkill River cutting Ordovician shales and siltstones on the right.
25.8	2.4	Rondout Creek cutting Ordovician shales and siltstones. Lefever Falls (rapids) on the left. This is about the northernmost extent of Ordovician outcrops along the Thruway in the field trip area (Fig. 1).
27.0	1.2	Underpass NY 32. For the next 5.3 miles there are intermittent outcrops and road cuts in a more or less regularly ascending order of formations from Kalkberg (Lower Devonian) through Onondaga (Middle Devonian). High speed traffic does not permit close observation.
32.4	5.4	N.Y. Central Railroad.
32.7	0.3	Esopus Creek.
32.9	0.2	NYS Thruway Exit 19 (Kingston). Bear right.
33.3	0.4	Toll Booth, NYS Thruway Interchange 19. Proceed southwest and enter traffic circle. Keeping right, bear onto NY 28 heading northwest.
33.7	0.4	Traffic light. Just past light bear right toward US 209 By-Pass and Kingston-Rhinecliff Bridge.
34.0	0.3	North on US 209 By-Pass. For the next 2.1 miles are extensive road cuts in gently dipping siltstones and shales of Mt. Marion Formation (Middle Devonian).
36.2	2.2	Pass over NYS Thruway.
36.6	0.4	Bridge over Esopus Creek. Mt. Marion (?) outcrop north of road and east of creek.

TOTAL MILES	Miles Between Points	
37.4	0.8	End US 209 By-Pass. Begin NY 199. Continue east.
37.5	0.1	Pass over US 9W.
37.6	0.1	STOP 1a: Road Cut in Esopus and Schoharie Formations: Pull off onto north side of highway with care. On this trip (Stops 1A-C) do not cross over onto south side of highway because of high speed traffic. Observe anticlinal exposure of upper (40-45') of Esopus Shale to the west and synclinal exposure of Schoharie Formation to the east. Contact between the two formations is covered but contacts, lithologies and thicknesses of the Carlisle Center, (including Black Bed), Aquetuck and Saugerties Members of the Schoharie can be observed. Fossils are best collected from the Saugerties Member. Sections of the feeding burrow *Zoophycos cauda-galli* are common in the Esopus Shale and Carlisle Center Member. Total extent of road cut is about 0.3 miles. Proceed east on foot along north side of highway right-of-way about 0.5 miles to the next stop.
38.1	0.5	STOP 1b: Road Cut in Glenerie, Port Ewen, Alsen and Becraft Formations: In this anticlinal exposure a partial section of Glenerie Formation and complete or almost complete sections of the Port Ewen and Alsen Formations can be closely examined on the western flank. A partial section of Becraft Limestone is exposed in the core of the structure. Although the contact between the Glenerie and Port Ewen Formations is covered, the Connelly Sandstone which intervenes to the south does not seem to be present here. The Port Ewen-Alsen-Becraft contacts are well-exposed. Some fossils can be collected in the Glenerie, Alsen and Becraft Formations. This road cut extends about 0.1 miles. Proceed east on foot along north side of highway right-of-way about 0.2 miles to the next stop.
38.3	0.2	STOP 1c: Road Cut in New Scotland, Kalkberg, Ravena and Thacher Limestones: In this road cut a sequence of west-dipping beds are exposed. From west to east these are: the New Scotland Formation (incomplete); the Kalkberg Limestone with its two members, the Broncks Lake and Hannacroix (complete); the Ravena Limestone, sole representative member of the Coeymans Formation (complete); and the Thacher Limestone, sole representative member of the Manlius Formation. The Thacher-Ravena-Kalkberg and possibly Kalkberg-New Scotland contacts are well-exposed. Fossils can be collected from all formations or members, but especially the New Scotland Formation. The brachiopod *Gypidula coeymanensis* is noteworthy in the Ravena and Hannicroix limestones but is difficult to obtain whole. Stromatoporoids are noteworthy in the Thacher Limestone. This road cut

FIG. 4

HORIZONTAL SCALE EQUALS VERTICAL



SKETCH OF STRATIGRAPHY AND STRUCTURE IN ROAD CUT NORTH END STOP 2A

1. RAVENA
2. THACHER
3. WHITEPORT
4. GLASCO
5. ROSENDALE
6. WILBUR
7. AUSTIN GLEN (?)
f. FAULT

TOTAL MILES	Miles Between Points	
		extends about 0.1 miles.
		Return to transportation at STOP 1a and continue east on NY 199.
38.6	0.3	Exit to NY 32. Bear Right (south then west). Last turn-off before Kingston-Rhinecliff Bridge!
38.8	0.2	Stop Sign. Turn left (south) onto NY 32. Proceed south 0.2 miles and pull off on west side of highway opposite road cut.
39.0	0.2	<u>STOP 2a</u>: <u>Road Cut Exposing Wilbur Limestone — Austin Glen (?) Graywacke Angular Unconformity</u>: Because of high speed traffic please <u>do not cross highway</u> on this trip. Here is exposed a slightly folded, but largely horizontal, bed of Wilbur Limestone (lowermost member of the Rondout Formation) indistinct angular unconformity with underlying graywackes of possible Austin Glen affinity. It is possible that the unconformity is actually a fault but the same relations obtain too often elsewhere to make this likely. Some fossils may be extracted from the Wilbur Limestone. <u>Coenites</u> is abundant locally.
		Proceed with care on foot south along NY 32 about 0.1 miles.
39.1	0.1	<u>STOP 2b</u>: <u>Road cut, Austin Glen (?), Rondout, Thacher and Ravena Formations and Members with Structural Complications. Watch for falling rocks</u>. This road cut extends for the next 0.3 miles. Starting from the north end there is a stratigraphic succession from Austin Glen (?) through Ravena Limestone which is somewhat complicated in the north half of the cut by faulting. Individual stratigraphic units are well exposed but Figure 4 should be consulted in order to verify their structural relations. The following Formations or Members are present and their lithologies and contacts (/) indicated:
		Ravena ls./Thacher ls./Whiteport dol./Glasco ls./ /Rosendale dol./Wilbur ls.~Austin Glen (?) graywacke
		A few fossils may be collected from all units except perhaps the Whiteport and Rosendale dolomites and the Austin Glen (?). Especially noteworthy are Cystihalysites and stromatoporoids in the Glasco limestone.
		Return to transportation and proceed south on NY 32.
		From the south end of STOP 2b (39.4 miles) south to the intersection of NY 32 and US 9W (42.3 miles) there are intermittent outcrops and road cuts in a more or less regularly ascending stratigraphic order from Austin Glen (?)

TOTAL MILES	Miles Between Points	
		through Onondaga Formations. The overall picture is somewhat complicated structurally. Of especial note however, is a two to three foot bed of Connelly Sandstone exposed at the south end of a road cut on the east side of the highway about mile 40.6 of this trip. Traffic does not permit close observation from a bus.
42.3	3.2	Traffic light. Intersection NY 32 and US 9W. Continue straight south on NY 32 (Flatbush Avenue, City of Kingston).
43.1	0.8	Traffic light. Turn sharp left onto Foxhall Avenue and proceed south.
43.3	0.2	Turn right at Chevron service station onto O'Neil Street and proceed southwest.
43.4	0.1	Traffic light.
43.8	0.4	Traffic light. Turn left on Broadway (NY 28) and proceed southeast.
44.0	0.2	Underpass. New York Central Railroad.
44.1	0.1	Trailways bus depot. Rest Stop. Continue south on Broadway.
44.6	0.5	Traffic light. End NY 28. Continue straight on US 9W South.
45.0	0.4	Traffic light. Keep right for thru-traffic.
45.1	0.1	Bear left on US 9W South.
45.4	0.3	Traffic light. Do not enter bridge south over Rondout Creek, but turn right on Abeel Street and proceed southwest.
45.9	0.5	Block Park on left.
46.4	0.5	Underpass. New York Central Railroad.
46.7	0.3	Traffic signal. Wilbur. Bear left onto NY 213 (continuing Abeel Street) southwest parallel to Rondout Creek. Prepare to pull off road to right suddenly in 0.6 miles. Park in entrance to gravel pit road if road is chained off. If road is open, do not block entrance.
47.3	0.6	STOP 3: City of Kingston Wilbur Gravel Pit; Standard Reference Section of the Rondout Formation and Type Section of the Wilbur Member; Intercalation of the Wilbur Member with Rosendale Member; Binnewater Sandstone disconformably underlying the Rondout Formation and overlying the Ordovician Austin Glen graywackes and shales in angular unconformity. Walk up road to gravel pit (northeast)

TOTAL MILES	Miles Between Points	
		about 0.1 miles. The cliff to the northwest is formed of an extensive sequence of Upper Silurian and Lower Devonian strata (mostly carbonates) partly repeated by faulting. Rickard (1962, p. 30) suggested that the standard reference section for the Rondout Formation be located in this quarry and Hoar and Bowen (1967, p. 4) designated this locality as the type section for the Wilbur Limestone Member which here intertongues with the Rosendale Member (Fig. 2). Disconformably underlying the Rondout Formation is the Binnewater Sandstone which is absent further north (STOP 2a, 2b) and which, at the present stop, overlies graywackes and shales of Austin Glen (?) affinity with angular unconformity.
		Return to transportation and continue southwest on NY 213 along southeastern base of Fly Mountain Ridge.
47.6	0.3	Pass under Nytralite conveyor.
47.8	0.2	Keep straight southwest onto Mountain Road; NY213 bears left. Continue parallel to Fly Mountain ridge on the right.
48.5	0.7	Stop Sign. Turn right (southwest) onto De Witt Lake Road. Continue parallel to Fly Mountain ridge on the right.
49.3	0.8	Stop Sign. Turn left (south) onto NY 32.
49.4	0.1	Bear right onto Beversoorfer Street.
49.6	0.2	Junction with Whiteport Road on right. Continue straight (left) on Beyersoorfer Street.
49.7	0.1	Park near entrance to NY 32. Walk 0.1 miles north (down hill) on west side of highway to road cut. <u>Do not stand on highway or cross to other side</u> on this trip because of high speed traffic and blind hill.
		<u>STOP 4: Road Cut NY 32, Bloomington Vicinity; Glenerie, Connelly and Port Ewen Formations:</u> Here is exposed an almost continuous sequence of northwest-dipping beds of the upper part of the Port Ewen Formation (up hill) through the Connelly Sandstone into the lower part of the Glenerie Formation (downhill). The Connelly Sandstone has thickened considerably from the two or three foot exposure about one mile south of Stop 2a. Layers of abundant brachiopods exposed in section can be seen in the Glenerie limestones but collection in the round will prove difficult.
		Return to transportation and bear right continuing south on NY 32.

TOTAL MILES	Miles Between Points	
50.9	1.2	Northern approach to bridge over NYS Thruway. Turn left off NY 32 onto Alberts Avenue. Proceed 0.2 miles on dirt road and park beyond garages on the right. Walk north uphill on dirt road about 0.1 miles to quarry in shales and siltstones.
		STOP 5: South End Quarry Hill; Binnewater Sandstone — High Falls Shale — Shawangunk Conglomerate — Snake Hill (?) Sequence: Examine the disturbed siltstones and shales of Ordovician Snake Hill (?) aspect then examine the northwesterly dipping partly covered sequence of beds between the quarry and the edge of the mine pit to the west. Don't crowd edge of pit! From west to east the formations present are: Binnewater Sandstone (partly covered), Highfalls Shale (largely covered), Shawangunk Conglomerate, Snake Hill (?) shales and siltstones. The Binnewater —High Falls contact is covered but the High Falls—Shawangunk—Ordovician shale contacts are fully exposed. Noteworthy is the two to three foot thickness of Shawangunk Conglomerate and its relatively dark color (typical of the top of the formation locally). Also of note is the first two or three feet of shale beneath the conglomerate. This shale seems to differ from more typical Ordovician shales which underlie it. The mine pit to the west is excavated in a fault-complexed body of Rosendale Dolomite. The far wall (west) of the pit from bottom to top reveals a normal sequence of Glasco Limestone (ledge), Whiteport Dolomite (lower portion mined out) and lower part of the Thacher Limestone (upper part of the cliff).
		Walk back to transportation and return to NY 32.
51.2	0.3	Stop Sign. Turn left onto NY 32 and continue south.
51.3	0.1	Pass over NYS Thruway.
51.7	0.4	Turn right onto Old NY Route 32. Proceed south.
52.2	0.5	Kallops Corners. Bear right.
52.5	0.3	Junction of Breezy Hill Road (from left) and Hickory Bush Road. Continue straight (north) on Hickory Bush Road. Caution, narrow road, blind hill and children at play (usually).
53.1	0.6	Abandoned natural cement kilns on roadside to right. Turn sharp left into open field and head toward distant kilns to the west by following dirt road left then right.
53.3	0.2	Park in front of kilns. Walk uphill to the right (north) over a glaciated shale outcrop of Snake Hill (?) affinity, then bear northwest over rubble pile and continue west at top of hill to New York Central Railroad tracks. Total distance is about 0.1 miles.

TOTAL MILES	Miles Between Points	
		STOP 6: Fourth Lake; Rosendale Member Type Section; Ordovician, Snake Hill (?) Shale, High Falls Shale; Rondout Formation; Thacher Limestone (part) Sequence: Walk north (right) about 0.05 miles along track to rail road cut in Ordovician shales of Snake Hill (?) affinity. Retrace steps south about 0.07 miles along west side of track examining soil of covered interval for first signs of red shale particles (High Falls). Because traces of the Shawangunk Conglomerate are lacking and because the formation is not exposed locally, it is assumed that the High Falls Shale is in direct contact with the Ordovician shales even though the contact is covered at this Stop and not exposed locally. Continue walking south to the partly covered contact between the High Falls Shale and the Binnewater Sandstone. For the next 0.1 miles in the railroad cut along the west side of the track is exposed a continuous sequence of northwest-dipping strata including uppermost High Falls (north) through Binnewater, Rosendale, Glasco, Whiteport and lower Thacher (south) members and formations. Examine the various units in light of general descriptions in the text. Contacts between units should be observed — some with caution. Except for pillars the bulk of the Rosendale and lower Whiteport members has been mined out. Please do not fall into the pits. Hoar and Bowen (1967, p. 4) has designated this locality the type section of the Rosendale Dolomite Member of the Rondout Formation.
		Return to transportation and drive back to field entrance.
53.4	0.1	Leaving open field turn right and proceed south on Hickory Bush Road.
54.1	0.7	Junction of Hickory Bush and Breezy Hill Roads. Turn right and proceed west then southwest on Breezy Hill Road.
55.0	0.9	Stop Sign. Keators Corner (Binnewater). Cross New York Central Railroad track and turn right (north) onto Binnewater Road.
55.3	0.3	Proceeding straight ahead (north) leave Binnewater Road and enter Williams Lake Hotel property.
55.4	0.1	Keep straight ahead (northeast).
55.5	0.1	Turn right across railroad track into private turning area and park so as not to block access. Walk back to track then right (north) along railroad to railroad cut.

TOTAL MILES	Miles Between Points	
		<u>STOP 7: Williams Lake; Rondout Formation; Binnewater Sandstone; High Falls Shale; Shawangunk Conglomerate Sequence:</u> For the next 0.1 miles north in the railroad cut on both sides of the track is exposed a continuous sequence of westerly-dipping strata which include the Whiteport (south) through Glasco, Rosendale, Binnewater, High Falls and Shawangunk (north) members and formations. The various units and their contacts (where exposed) should be examined in light of general descriptions in the text. The Shawangunk Conglomerate, apparently absent at Stop 6, is well-developed here as well as locally, but the Shawangunk-Ordovician angular unconformity is not exposed.
		Return to transportation and drive south to exit from Williams Lake Hotel property.
55.8	0.3	Stop Sign. Proceed straight ahead (south) onto Binnewater Road.
56.0	0.2	Keators Corner (Binnewater). Continue south on Binnewater Road. Rosendale Hill lies directly ahead.
56.6	0.6	Century Cement Company natural cement kilns on right. These are still in occasional operation.
57.0	0.4	Stop Sign. Turn right (southwest) onto NY 213.
58.1	1.1	Bridge over Rondout Creek.
58.2	0.1	Extensive cliffs on right are formed by New Scotland Formation.
59.3	1.1	Bear right onto side road (High Falls).
59.5	0.2	Bear left.
59.6	0.1	Park opposite Mobile gasoline station. Walk ahead about 0.05 miles to NY 213. Walk uphill (east) along north side of highway. <u>Do not cross highway; heavy traffic</u>.
		<u>STOP 8: High Falls, NY 213 Road Cut; High Falls Shale — Shawangunk Conglomerate Contact:</u> Examine slightly anticlinal, light-colored exposure of Shawangunk conglomerate along extent of road cut (about 0.05 miles). Note the High Falls — Shawangunk contact at the east end of the cut (uphill) and determine whether it is distinct, conformable, gradational and/or interbedded. Note the dark color of the uppermost conglomerate layer.
		Return to transportation and proceed to main highway.

TOTAL MILES	Miles Between Points	
59.7	0.1	Stop Sign. Turn right (west) onto NY 213.
59.8	0.1	Sign on right noting the discovery of natural cement at nearby Bruceville in 1818. Just ahead is a section of the Delaware and Hudson Canal. The recently formed (1966) Delaware and Hudson Canal Historical Society plans to restore to operating condition some of the canal locks at High Falls. The canal played an important part in the transportation of natural cement and coal in the latter half of the nineteenth century.
60.1	0.3	High Falls and Central Hudson generating facilities on the right. The face of the falls is formed of the Glasco Limestone and Rosendale Dolomite members of the Rondout Formation. Extensive exposures of Binnewater Sandstone and High Falls Shale occur from the base of the falls downstream.
60.2	0.1	Bridge over Rondout Creek.
60.3	0.1	Turn left (south) off NY 213 and proceed south on newly paved (county) road.
62.1	1.8	Outcrops and road cuts for the next 0.4 miles reveal a succession of strata from the New Scotland Formation (north end) through the Whiteport Dolomite in the bed of Kripplebush Creek at mile 62.5 (south end).
63.4	1.3	Crossroad. Keep straight.
64.2	0.8	Outcrops and road cuts for the next 0.4 miles expose Glasco and Rosendale limestones.
65.6	1.4	Stop Sign. Turn left (west) onto US 299.
66.4	0.8	Turn left (south) with care off US 299 into Accord (formerly Port Jackson). Just ahead is bridge over Rondout Creek.
66.5	0.1	Turn right down side road just past bridge.
66.6	0.1	Road fork. Bear right.
66.7	0.1	Bear right onto main road then immediately right onto road with Dead End sign. Proceed past sign 0.1 miles bearing left then right into Town of Rochester Highway Department yard. Park (mile 66.9). Walk a short distance southeast over abandoned road and descend into abandoned railroad cut. Walk to east end of cut.

STOP 9: Abandoned New York, Ontario and Western Railroad Cut at Accord; Glasco Limestone (part), Rosendale limestones and Bossardville ? Formation (Accord Shale) Sequence:
Walk west in cut and observe the following sequence: stromatoporoidal limestone of the Glasco Member overlying highly calcareous Rosendale member (compare

TOTAL MILES	Miles Between Points	
		with Rosendale at Stops 2, 6 and 8) which contains a highly arenaceous unit at the base and which overlies a laminated soft-weathering argillaceous dolomite and dolomitic shale (compare with Binnewater Sandstone and thin interbedded shales at Stops 6 and 7). The argillaceous, dolomitic beds here are tentatively assigned to the Bossardville Formation. They have also been referred to as the Accord Shale (Fisher, 1960). Extent of cut is about 0.1 miles.
		Time permitting, visits may be made to nearby quarries in the Rosendale limestones and in the Thacher and Ravena Limestones.
		Walk back to transportation and return to main road.
67.1	0.4	Turn right (west) onto main road.
67.2	0.1	On left is entrance to quarry largely excavated in Rosendale limestones. Road skirts northwest side of quarry.
68.1	0.9	Outcrop of Shawangunk Conglomerate on left.
69.4	1.3	Entrance to the Granit on left.
69.8	0.4	Junction. Bear left.
70.1	0.3	Cross bridge, then bear right.
71.0	0.9	Stop. Turn sharp left onto US 44 - NY 55 and proceed south.
72.0	1.0	Begin ascent of the general dip slope of the Shawangunk Mountains. For the next 6.1 miles the Shawangunk conglomerates and orthoquartzites which, in effect, sheath the Shawangunk Mountains, crop out extensively giving rise to typical Shawangunk Mountain topography.
75.4	3.4	Entrance to Minnewaska Lodge on left. Keep straight.
76.3	0.9	Ordovician shales of Snake Hill (?) aspect on the right. This exposure is part of an Ordovician shale window in the Shawangunk Conglomerate. Several years ago a very deep, very dry, wildcat was drilled in this window.
78.1	1.8	Bridge underpass. Lowermost part of the Shawangunk Conglomerate is exposed in the road cut just east of the bridge.
78.2	0.1	Exposure of Ordovician shales of Snake Hill (?) aspect to the left. View of the Mid-Hudson Lowlands to the east and on a clear day, the Hudson Highlands to the southeast. Begin descent of Shawangunk Mountains.
78.4	0.2	Shear cliffs of the eastern face of Shawangunk Mountain cuesta tower on the left, capped by almost two hundred feet of conglomerate and ortho quartzite. These cliffs are much used for practice in mountain-climbing

TOTAL MILES	Miles Between Points	
		as they present most, if not all grades of climbs. On weekends and holidays the cliffs are well-populated with climbers from many states and Canada.
		The sport is not without risk; at least two climbers have "come off" here in the last three years.
78.7	0.3	Slow! Switch-back.
79.6	0.9	Junction. Turn left onto NY 299 and proceed northeast through countryside underlain by Ordovician shale and siltstones of Snake Hill (?) affinity.
85.4	5.8	Bridge over Wallkill River. Enter New Paltz and continue east on NY 299 (Main Street). The State University College at New Paltz is located here.
85.45	0.05	New York Central Railroad crossing.
85.6	0.15	Junction with NY 32 on left (north) and NY 208 on right (south). Keep straight on NY 299.
85.8	0.2	NY 32 north on left.
86.0	0.2	Traffic light. NY 32 south on right. Keep straight on NY 299.
87.1	1.1	Entrance to NYS Thruway. Bear right (south).
87.3	0.2	NYS Thruway toll booth, Interchange 18 (New Paltz). Proceed south on Thruway toward New York City.
103.6	16.3	Bear right for NYS Thruway Exit 17 (Newburgh) and proceed east past toll booth.
104.4	0.8	Keep left for NY 17K.
104.6	0.2	Bear right for NY 17K.
104.8	0.2	Bear right onto NY 17K and proceed west.
104.9	0.1	Traffic light. Continue straight (west).
105.1	0.2	Turn right for Holiday Inn, Newburgh, New York.

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Topographic:

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Kingston West, N.Y.	1942, 1964 edition	
Rosendale, N.Y.	1942, 1964 edition	
Mohonk Lake, N.Y.	1942, 1964 edition	

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GEOLOGIC STRUCTURE OF THE KINGSTON ARC OF THE APPALACHIAN FOLD BELT

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The Appalachian orogen when observed in its areal extent from Alabama to Newfoundland shows in its pattern a series of arcs, some bowed northwestward toward the foreland, others bowed inward toward the eugeosynclinal belt. One of the more prominent of these arcs, bowed eastward and southeastward toward the crystalline core of New England, is located at Kingston, New York, its hing-zone being situated in the old Rondout and Wilbur districts of the City of Kingston. The western extremity of the arc lies in the vicinity of Rosendale, and in its northern extension continues to the environs of East Kingston and the Kingston-Rhinecliff Bridge on the Hudson River.

The type of deformation evident within the Kingston Arc may be of some interest to the structural geologist and the purpose of this field trip is to observe the geologic structure at several localities where exposures are favorable.

The scheduled stops are as follows:

STOP I: The Nytralite Quarry, Route 32, Fly Mountain, about three quarters of a mile west of Kingston.

STOP II: (a) Callanhan's Quarry, south of Rondout Creek, opposite Wilbur in Kingston, 5.2 miles from the Nytralite Quarry; (b) West Shore R.R. cut about one quarter mile east of Callanhan's Quarry.

STOP III: The series of road cuts along Route 199 three miles north of Kingston.

STOP IV: Outcrops at Glenerie Falls, Route 9W about 6.3 miles north of Kingston.

TABLE I.

AN ABBREVIATED AND SIMPLIFIED SEQUENCE OF THE ROCK UNITS EXPOSED IN THE KINGSTON ARC SECTOR

(compiled from Chadwick (1933), Johnsen (1962), Oliver (1962), Rickard (1962), Van Ingen (1903).

DEVONIAN

Rock Unit	Thickness in Feet
Onondaga Formation Five subunits of differing carbonate lithology	165+
Schoharie Formation Transition zone of clastic carbonate rock	220
Esopus Shale Massive silty shale, black to olive-brown	150
Glenerie Formation Siliceous limestones and/or sandstones	60
Port Ewen Limestone Dark gray siliceous and argillaceous limestone	140
Alsen Limestone Light gray limestone	20
Becraft Limestone Massive, semi-crystalline limestone	40
New Scotland Limestone Dark gray shaly limestone	100
Kalkberg Limestone Massive, dark gray argillaceous limestones and chert beds	38
Coeymans Limestone Dark gray massive limestone	13
Manlius Limestone Fine to medium-grained dark blue limestone	48

SILURIAN

Rock Unit	Thickness in Feet
Rondout Limestone Argillaceous dolomite to fine-grained limestone	39
Binnewater Sandstone Blue-gray quartz sandstone	0 to 13

angular unconformity

ORDOVICIAN

Rock Unit	Thickness in Feet
"Hudson River Beds" (Normanskill and/or Martinsburg) Gray, gray-brown shales and sandstones	1000+

FIELD TRIP
DESCRIPTION OF SCHEDULED STOPS

Co-Leaders: George R. Heyl and Morris Salkind

STOP I: The Nytralite Quarry on Route 32 is developed in the Esopus Shale. The operations of this company extend on both sides of the highway. Shale is trucked from the quarry floor to the crushers on the ridge of Fly Mountain, where the material is processed. It is then heated in the kiln, causing the shale to expand. A conveyer leads down the south side of Fly Mountain, where the expanded shale is loaded on barges in Rondout Creek to be carried down the Hudson River to markets in the New York City area. Trucks are used to carry the expanded shale to customers in the Mid-Hudson area.

Though the Esopus Shales are not highly resistant to erosion, in this area they commonly are minor ridge-makers. Where exposed, they show as massive blocks whose bedding is difficult to follow, but whose cleavage is readily apparent. The cleavage may therefore be easily mistaken for the bedding in an outcrop.

Both the cleavage and the extensive fracture pattern in the shales is reflected in details of the topography of the region. The strongly-cleaved shales are more easily eroded and the intersection of the cleavage with the accompanying joints results in the appearance of gently sloping planes dipping in various directions where the shales are exposed (Fig. 1 - The vertical lines indicate cleavage).

Where freshly exposed, the shales appear black, blue-black, or olive-brown. Often they show vertical white bands, a result of re-deposition on their cleavage surfaces of some of the minerals dissolved from the shale.

Weathering of the shales will often bring out color changes that emphasize the bedding planes. Occasional lenses or thin layers of other material, e.g., sand, help in the delineation of the bedding. Where the shales have been exposed to weathering, some of those having a greater lime content will show a grayer surface.

At this locality the beds are generally more gently dipping than the cleavage. The response of the shales to folding was not paramount; they show some flexures, but the continued impress of the deforming forces caused the shales to shear rather than to fold. Shear planes present in some cases cut across the cleavage. Where a conjugate set of shear fractures exist they are parallel to the cleavage (Fig. 3). The cleavage is generally parallel to the strike of the beds. However, it should be evident that strike joints will generally merge with the strong cleavage.

Occasional fossil shell fragments can be found in the shales. Nodules of pyrite are frequent.

STOP IIa: Callanhan's Quarry is in the village of Connelly south of Rondout Creek. From the quarry floor, facing northeast, approximately 170 feet of limestones have been exposed by the quarrying operation. There are three areas or "pits" where the quarrying operations take place all at varying distances from the northwest-southeast section line drawn across the quarry floor. In the accompanying section, the pits are labeled by number (Fig. 5).

The limestone, commercially known as "traprock", is crushed to different sizes after being blasted from the walls of the quarry. It is used primarily in various kinds of construction such as road metal for highways, and concrete aggregate for building construction. The Rondout Creek is used to transport bulk shipments of the material.

The limestones show three major high-angle reverse faults cutting through all the beds exposed in the quarrying operation. There are numerous smaller faults. Looking to the southeast, one can see near-vertical faces of limestone. Bedding-surface slickensides are commonly seen in the quarry, for example, between the Alsen and Becraft units and within the New Scotland limestones.

The exposed southeast side of Pit I shows an extensive slickensided surface over much of its length. Also on this same surface and extending for many feet parallel to the slickensides are thick, rod-like mullion structures. The limestones in this pit are gently folded.

In Pit 2 there is an extensive fault zone which includes a major fault. Toward the southeast the quarry wall is near-vertical and shows extensive slickensides. There the beds are bent in a circular arc at the southeastern end of this section, and are folded synclinally.

The sharp folds are continued into Pit 3. Here the Becraft-New Scotland exposures are near vertical and show extensive slickensiding within the New Scotland beds.

STOP IIb: This stop is in the cut of the West Shore R.R. about one quarter mile east of Callanhan's Quarry. Near the road coming from the floor of the quarry to where it intercepts the railroad track there are exposures of the Hudson River sandstones. The contact of the Ordovician sandstones and the Silurian is not visible here. The Kalkberg and New Scotland beds can be seen just west of the railroad right-of-way. The Becraft limestone outcrop, to which an abandoned wagon trail leads, was mined in earlier years at this site. Many of the abandoned quarries in the Kingston area formerly exploited the Becraft or the Rondout limestones.

Of the quarrying operations the main evidence is a 100-foot shaft situated between the New Scotland and the Alsen through which the Becraft was removed. At the lowest part of the north wall in this shaft one can see part of the synclinal fold in the Becraft, which was also visible from the floor of Callanhan's Quarry. The railroad cut farther northward exposes the Port Ewen limestone (and its time-correlative deposits - the Connelly). The Port Ewen alternates with the Glenerie in exposures along the railroad tracks.

STOP III: This stop will be made along that section of Rt. 199 extending between Rt. 32 to Rt. 9W. (Approximately one quarter mile south of the entrance to Rt. 199 on Rt. 32 there is a good exposure of the angular unconformity between the Ordovician beds and overlying Silurian limestone). Along Rt. 199 the road cut exposes relatively gentle folding in the Devonian beds (Fig. 6). There are two low concealed areas in the section which are covered by swamp deposits and alluvium.

STOP IV: This stop is at Glenerie Falls and Rt. 9W approximately 6.3 miles north of Kingston. A plan view of the shear structures and the cleavage in the Glenerie Formation in this area is included (Fig. 4). The pattern which is shown in the plan view is seen as a side view where the Glenerie is visible along the highway. Some of the Glenerie exposures along the highway reflect the shear pattern so that the exposed blocks show as rectangles at times pointing toward the highway and at other times away.

The Esopus Creek which upstream meanders through its valley for several miles turns sharply to the east at Glenerie Falls and then flows north again at the foot of the Falls. Beyond, it continues between the confining Esopus Shales and the Glenerie, and has an approximately straight course almost to its mouth; it makes a bend at Saugerties and flows into the Hudson.

The rocks at the Falls clearly express the shear structure in the area. The weak, overlying Esopus Shales are being rapidly eroded. The presence of the Falls indicates a relatively youthful expression of the topography for the falls have not yet been planed down to grade.

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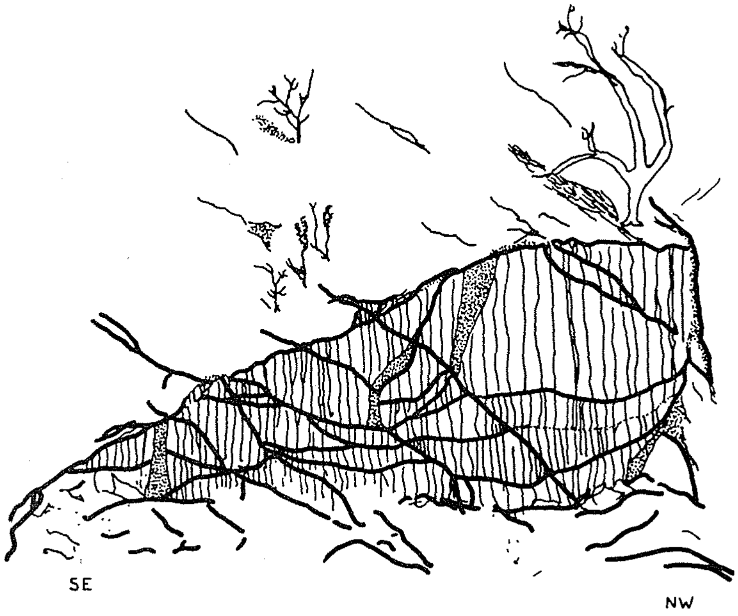

FIG. 1 ESOPUS SHALES EAST RT. 32 (STOP 1)
FACING SOUTHWEST
APPROXIMATELY 30FT X 70FT

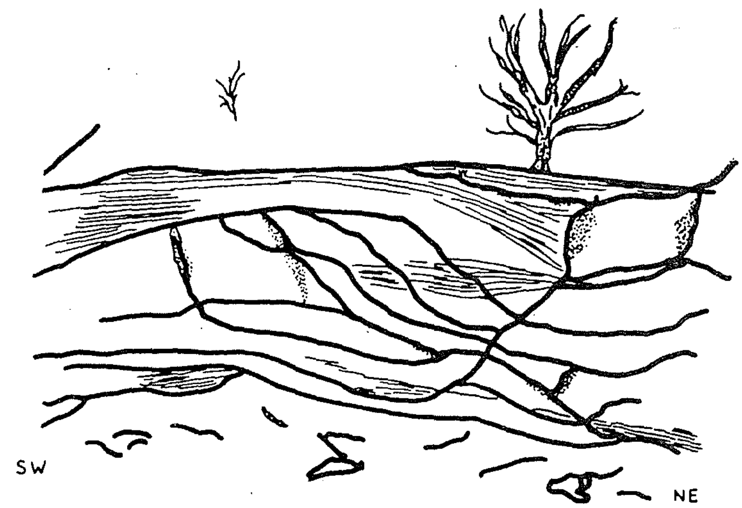

FIG. 3 ESOPUS SHALES WEST RT. 32 (STOP 1)
FACING NORTHWEST
AT RIGHT ANGLES TO CLEAVAGE
APPROXIMATELY 60 FT X 180 FT

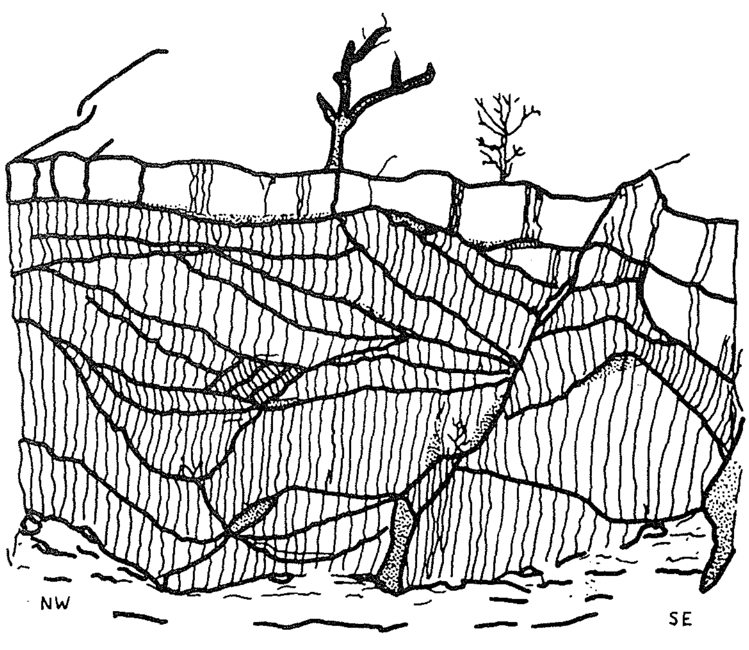

FIG. 2 ESOPUS SHALES WEST RT. 32 (STOP 1)
FACING NORTHEAST
APPROXIMATELY 35FT X 70FT

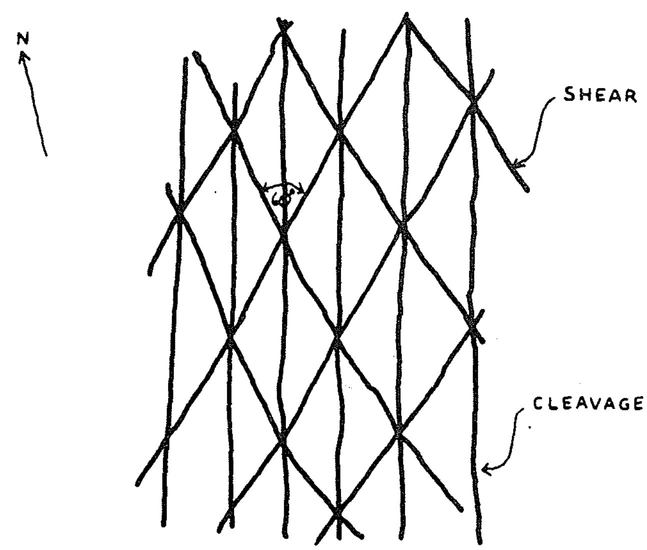

FIG. 4 GLENERIE ARENACEOUS LIMESTONE
GLENERIE FALLS (STOP 4). PLAN VIEW OF
SHEAR PATTERN PERPENDICULAR TO BEDDING
APPROXIMATELY 3FT X 5FT

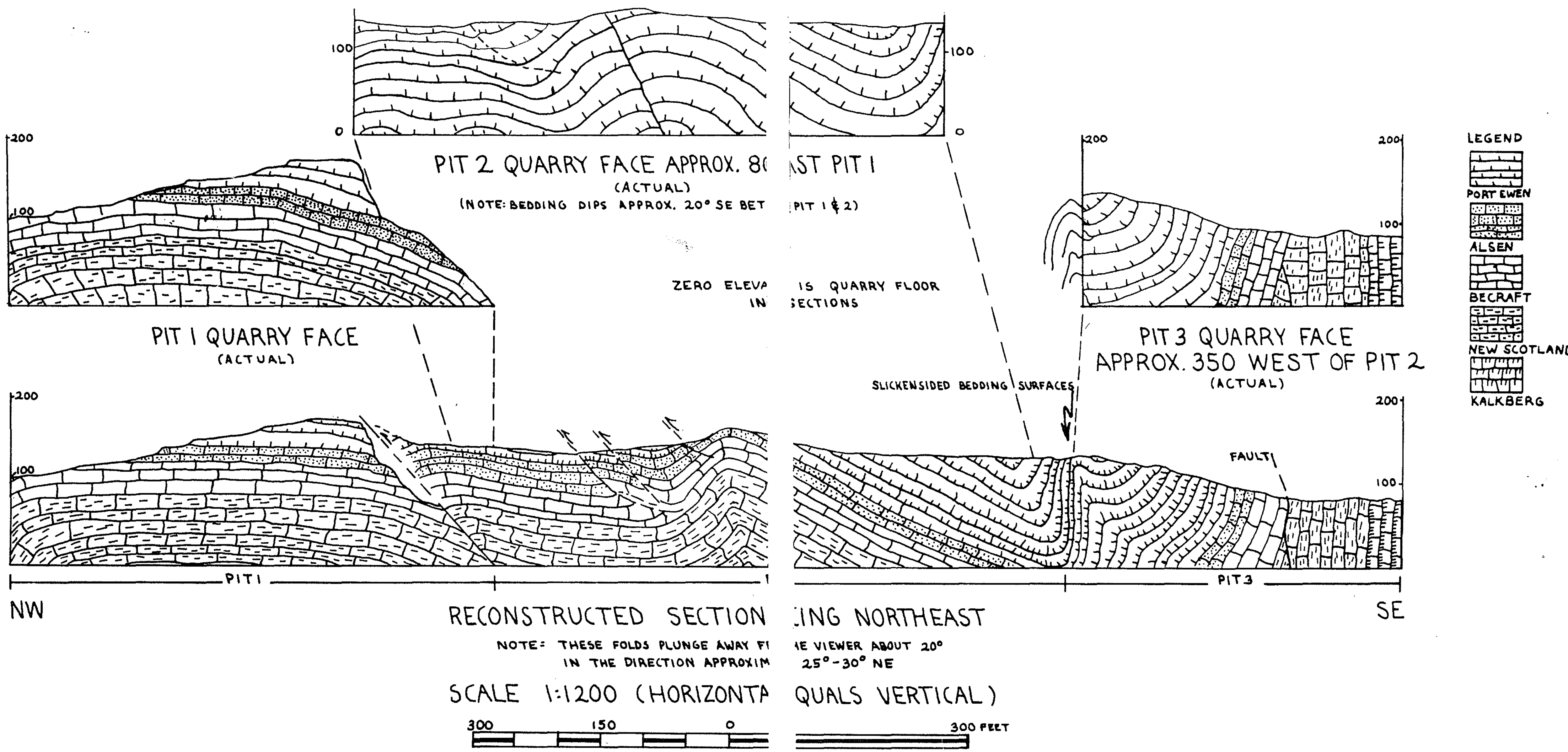

FIG. 5 CALLANHA) QUARRY

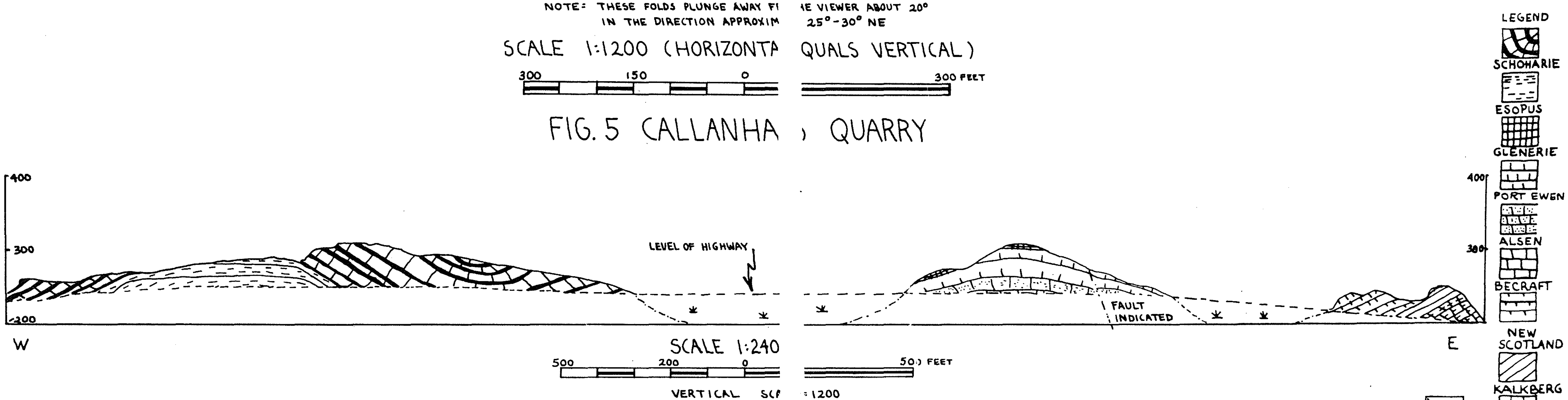

FIG. 6 RT 199 TO KINGSTON HINECLIFF BRIDGE

(FACING NO( )

DASHED LINE IS ELEV. 199

STRUCTURE AND PETROLOGY OF THE PRECAMBRIAN ALLOCHTHON AND PALEOZOIC SEDIMENTS OF THE MONROE AREA, NEW YORK

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INTRODUCTION

The area covered by this trip lies in the northern part of the Monroe 7 1/2' quadrangle, New York, and consists of a folded and faulted complex of autochthonous Precambrian gneisses, Lower Cambrian through Middle Devonian sediments and allochthonous Precambrian gneisses. Geologic maps covering the trip area have been published by Ries (1897), Fisher, et. al. (1961), and Jaffe and Jaffe (1962). Unpublished maps prepared by Colony and by Kothe (Ph.D. thesis, Cornell Univ.) undoubtedly contain valuable information but are not available for study. Recent workers in adjacent areas include Dodd (1965), Helenek (in progress) and Frimpter (in progress), all in the Precambrian autochthon, and Boucot (1959) and Southard (1960) in the stratigraphy and paleontology of the Paleozoic sediments. The work of Colony (1933), largely unpublished, is impressive.

An attempt to unravel the complex structural history of the region has suggested the following sequence of events:

1) Deposition in the Precambrian of a series of calcareous, siliceous, and pelitic sediments and basic volcanics of the flysch facies in a eugeosyncline; folding and metamorphism involving complete recrystallization to granulite facies gneiss assemblages which characterize the Precambrian autochthon (Jaffe and Jaffe, 1962; Dodd, 1965). Foliation in the autochthon trends northeast and is generally vertical or dips steeply to the east, with overturning west; fold axes most often plunge gently northeast. The metamorphic foliation appears essentially Precambrian in origin. The present Precambrian allochthon was deposited and recrystallized at about the same time as the autochthon recrystallization took place about 1100 million years ago. The sediments of the allochthon are graphitic, siliceous, calcareous and pelitic and appear to represent a clastic wedge (molasse) deposited in a reducing environment, possibly to the east. Graphitic gneisses are absent from the autochthon of the Monroe quadrangle, although they do occur in the Popolopen Lake quadrangle autochthon to the east (Dodd, 1965).

2) After extensive erosion, the Lower Cambrian Poughquag conglomerate, arkose, and quartzite were deposited unconformably on the Precambrian autochthon. As in most of the Hudson Highlands, the Poughquag has been only sporadically preserved and here occurs only in the buttressed area northeast of Block 2 (Fig. 2). The Poughquag dips gently to the north.

3) Deposition of the Cambro-Ordovician Wappinger Formation, which in this area consists entirely of dolomite. In Block 2 (Fig. 2), it also dips gently to the north. In Block 3 it is moderately to strongly folded along a northeast trend. In Block 5 it outcrops between the Ordovician shales and the Precambrian of Goose Pond klippe in a northeast-striking band that dips west. In about this same attitude it underlies the Precambrian Museum Village klippe in Block 9.

4) Intrusion of lamprophyre dikes into northwest-trending tension-fractures in Precambrian and overlying Cambro-Ordovician rocks (Jaffe and Jaffe, 1962). These dikes have been found only in Blocks 1, 2, and 3.

5) Deposition of the Hudson River shales (Middle? Ordovician) over the entire area. This was followed by either:

   a) gentle folding, followed by erosion, or

   b) upfaulting of the Wappinger dolomite against the shales.

6) Overthrusting of the Precambrian allochthon as a nappe from the east, most probably during the Taconic orogeny. Evidence for thrusting is:

   a) GEOMAGNETIC. The Precambrian autochthon everywhere shows a strong positive anomaly, whereas the klippen show none and can therefore be no more than 500-600 feet thick (R.W. Bromery, personal communication). The relief of Goose Pond Mountain is of this magnitude. Bull Mine Mountain, which contains a magnetite deposit, does show a positive anomaly.

   b) GEOLOGIC. The Precambrian of Bull Mine Mountain is perched on Ordovician shale; the Museum Village klippe can be seen to rest on Wappinger dolomite. At the base of Goose Pond Mountain is a fault breccia; such a zone also exists on Bull Mine Mountain at the contact of the shales and the gneiss.

   Near the klippen, the Ordovician shales are always more strongly folded than elsewhere in the area, and are often overturned.

   c) PETROGRAPHIC. Quartz pebbles and grains, commonly optically continuous except for strain, have length-width ratios up to 17:1. The texture of the klippe gneisses is consistently more deformed and cataclastic than that of the Precambrian autochthon.

7) Folding of the nappe along a northeast axis, followed by erosion, leaving (a) synclinal remnant (s) along the fold axis, extending from Goose Pond Mountain to Snake Hill, near Newburgh, and beyond, to just west of Balmville. The klippen must once have formed such a single line as would be left by an eroded downfold; the alignment from Bull Mine to Snake Hill is too perfect to be a coincidence, and Goose Pond Mountain is on strike with a klippe west of Balmville, a town just north of Newburgh.

8) N 75 W cross-faulting along the Quickway (N.Y. 17) with the north block moving east. This accounts for the present displacement of the Bull Mine-Snake Hill line of klippen from the Goose Pond klippe (The Museum Village klippe has been rotated from this line by a later fault, presumably Triassic). Apparent displacement is about one mile. The upper calcareous feldspathic quartzite member of the Hudson River shales, which outcrops on Lazy Hill, is essentially absent north of the Quickway fault. If its displacement north of the fault is the same as that of the line of klippen, its present position north of the fault is somewhere under the western talus slope of Schunemunk Mountain. Except for rotated Blocks 8 and 9, Silurian and younger formations line up on strike across the Quickway fault. The major lateral movement along this fault must therefore have been pre-Silurian.

9) After an erosion interval, the Shawangunk conglomerate and orthoquartzite (Lower to Middle Silurian) were deposited unconformably on the older rocks.

10) Deposition of Lower Devonian sediments.

11) Convincing evidence for the Acadian orogeny in the area is lacking. Such an event might account for pebble-stretching in the Shawangunk conglo-

merate, and for slight additional east-west movement along the Quickway cross-fault.

12) Deposition of the Cornwall shales and Bellvale graywackes in the Middle Devonian.

13) Appalachian folding. In the course of this folding, the relatively thin and brittle Shawangunk beds broke into detached plates which were thrust over the more yielding shales above and below. This thrusting produced the fluting parallel to the dip of the beds and the marked stretching of the Shawangunk pebbles in both the a and b fabric axes. Pebble beds in the thicker and more massive Bellvale graywackes show far less shattering and stretching of their pebbles.

14) Following the Appalachian revolution, the area was uplifted and has remained positive. During the Triassic orogeny, faulting, partly with and partly across the grain of the country, reactivated old faults and produced a complicated pattern of tilted and rotated, up- and down-faulted blocks:

   a) Block 1 (Fig. 2) was uplifted along a N33 E fault to form the Ramapo Mountains.

   b) Block 2, which includes Poughquag quartzite and Wappinger dolomite nestled in the curve of the Precambrian massif and dipping gently north, was uplifted. Block 2 is truncated to the north by an eastward continuation of the Quickway fault, as is shown by geomagnetic evidence (R.W. Bromery, personal communication; Henderson, 1962). Block 2 is in fault contact with the younger sediments of Blocks 3 and 4.

   c) Block 3 is a graben about 1500' wide at the south end of the map, and perhaps one or two miles wide at the north end of Block 2. In this graben, the Wappinger dolomite is moderately to steeply folded on a northeast axis.

   d) Block 4 was downfaulted relative to Blocks 2 and 5, and upfaulted relative to Blocks 6, 8, and 9. Anomalous northeast dips at the north end of Block 4 may be the result of drag during faulting.

   e) Block 5 was uplifted relative to Block 4, but downthrown relative to the klippen north of the Quickway fault. The Precambrian of Goose Pond Mountain outcrops from an elevation of 480' upward; the Museum Village klippe rests on dolomite at about 600'. The shale-gneiss contact on Bull Mine Mountain was observed at about 840'.

   f) The main mass of Schunemunk Mountain, Block 6, is downthrown along northeast-southwest faults on both sides. It must also be considerably downthrown relative to its continuation to the south (Block 4), which has a moderate positive geomagnetic anomaly indicating that the basement is not very far down. The syncline's east limb is truncated to the south.

   g) Block 7, in which the Esopus dips about 25° N and under which the basement anomaly is absent, probably was tilted to the north during the uplift of Block 2 and the sinking of Block 6.

   h) Block 8, where the synclinal axis of Schunemunk swings to north-south, has been rotated counterclockwise.

i) The Museum Village klippe and Bull Mine Mountain (Block 9), with the dolomite beneath, have also been rotated counter-clockwise as a single block.

j) The Shawangunk sliver between Blocks 8 and 9 has been ground, thrust, rotated and crumpled during the rotation of the blocks.

Interrelations of the faults are highly problematic, partly owing to the masking effects of the Pleistocene glaciation.

ROAD LOG TRIP F

Co-leaders: Howard W. Jaffe and Elizabeth B. Jaffe

MILEAGE

0.0	Holiday Inn, Newburgh, New York.
15.0	N.Y. Thruway south to Exit 16-Harriman.
15.1	First right turn after the toll booth.
15.2	Intersection with N.Y. 32.
15.25	Left on N.Y. 32, then immediately right on Dunderburg Road.
17.1	Left at T-intersection on N.Y. 208.
17.6	Bear right at fork on to Spring Street.
18.6	Bear right on North Main Street for 0.9 miles to outcrop.

19.5 STOP 1: Oreco Terrace: Bellvale Graywacke

The outcrop is on Oreco Terrace, just above the intersection of NY 208 and Oxford Road. Here, the Bellvale graywacke of the Hamilton Group (Middle Devonian) is exposed in a section approximately 220 feet thick. It consists of 20-40 foot beds of dark blue-gray, green-gray, or gray, fine- to medium-grained (.08-.25mm-avge. grain size) lithic arenite or graywacke, rhythmically interbedded with thin beds of dark green-gray to blue-gray shale. A representative modal composition of the graywacke follows:

Mode Of Bellvale Graywacke

Detritals:		
	quartz	20%
	oligoclase	2
	shale phyllite	44?
	siltstone chert	15
	greenstone	1
Matrix:	clay, sericite, chlorite, Mn oxide	15?
Metamorphic:		
	chlorite	2
	muscovite	1
		100%

Texturally, the rock consists of angular, elongated slivers of detrital quartz and predominantly phyllitic rock fragments (.08-.25mm) set in a fine matrix of sericitic muscovite, clay, and chlorite. It is often difficult to distinguish smeared-out phyllitic fragments from balled-up micaceous matrix, both of which frequently blend or flow together. Depending upon the uncertainty of the matrix content, or the classification used, the Bellvale is either a low-rank graywacke (Krynine, 1948), a subgraywacke or a lithic graywacke (Pettijohn, 1957) or a graywacke (Folk, 1954). Larger bent grains of chlorite and muscovite in the matrix, are here interpreted to have grown from fine matrix material, marking the beginning of the chlorite zone - greenschist facies of regional metamorphism imprinted during the Appalachian orogeny.

In general, the Bellvale graywackes tend to show rhythmic interbedding with shale, with graded bedding low in the section and strong current cross-bedding higher in the section. Occasional brachiopods are found low in the section; plant fossils are found higher up. Both features suggest a gradation from marine to nonmarine depositional environment. The provenance was a low-rank metamorphic or sedimentary terrane.

The shattered outcrop at Oreco Terrace is at the southwest corner of Rotated Block 8 (Fig. 2) and lies near the intersection of four directions of faulting. Attitudes of prominent structures at the outcrop are tabulated:

	Strike	Dip	Plunge
Bedding	N 67 W	30NE	—
Cleavage	N 50 E	37SE	—
Fault	N 13 E	Steep W	
Slickensides			45 N
Fault	N 38 E	Steep W	
Slickensides			60 N
Fault	N 30 W	52SW	
Slickensides			39 W

MILEAGE

Drive north about 0.9 miles on N.Y. 208 and turn left on small road for about 1000 feet.

20.4 STOP 2: Spring Glen Golf Range: Shawangunk Conglomerate

The Shawangunk conglomerate and quartzite (Greenpond conglomerate unit) of Lower to Middle Silurian age occurs in a series of small outcrops extending northeastward along the western edge of the Shunemunk Mountain syncline. At this stop the Shawangunk forms a small, relatively inconspicuous topographic knob as contrasted with its occurrence near Stop 5, where the same unit forms the spine of the steep, southeast-facing escarpment of Lazy Hill. At the present stop the Shawangunk consists of about 75% buff pebble conglomerate intercalated with 25% fine-grained green-gray quartzite.

The conglomerate consists of white pebbles of milky vein quartz (averaging 15-40mm in length) in a matrix of finer pebbles and grains of rounded quartz, all cemented by secondary silica and buff-orange-red ferric oxides. Occasional pebbles of white orthoclase are present as are black pebbles consisting of a mixture of green tourmaline and quartz. The color of the weathered surface of the outcrop varies from pink (hematite) to yellow-brown (goethite)

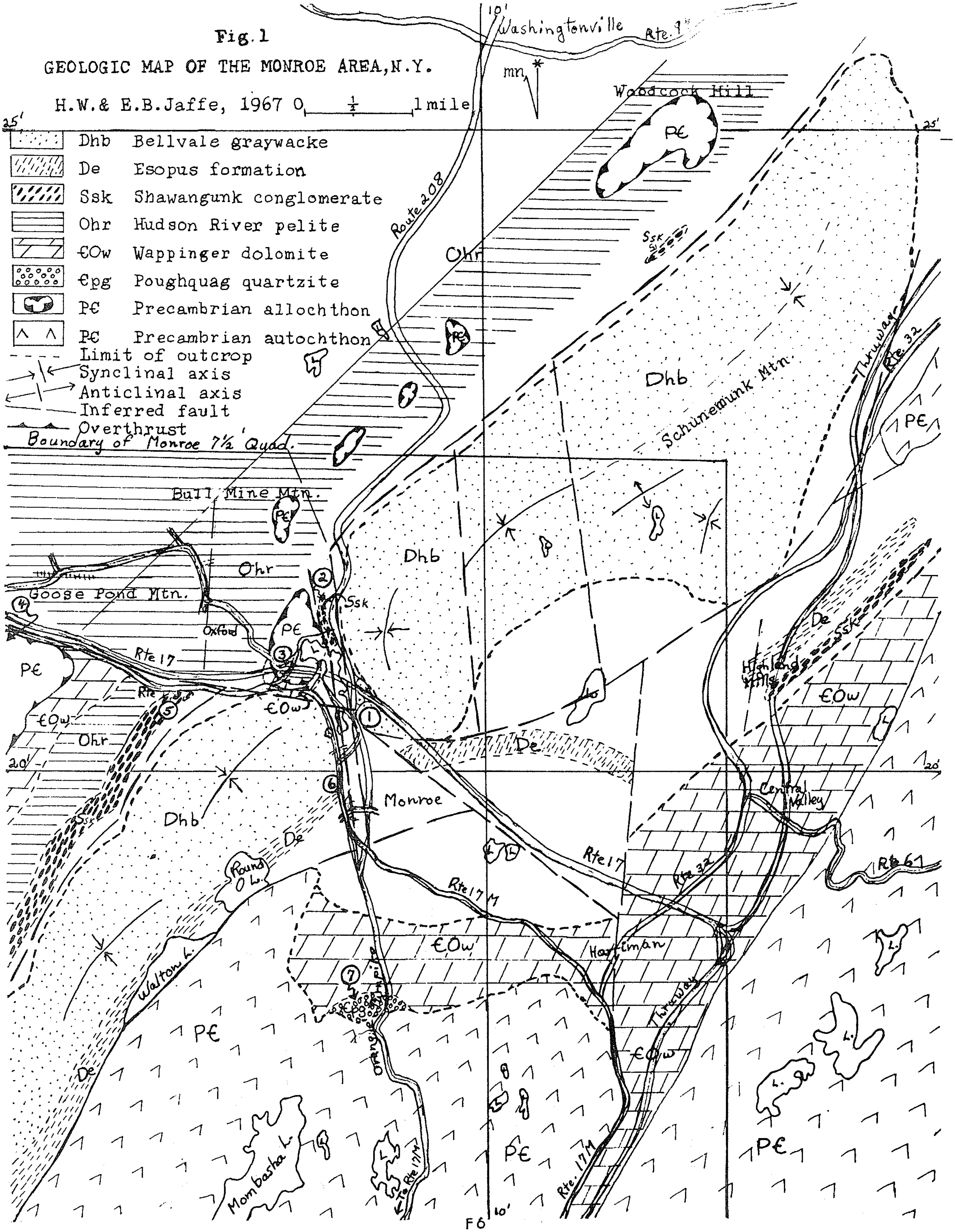
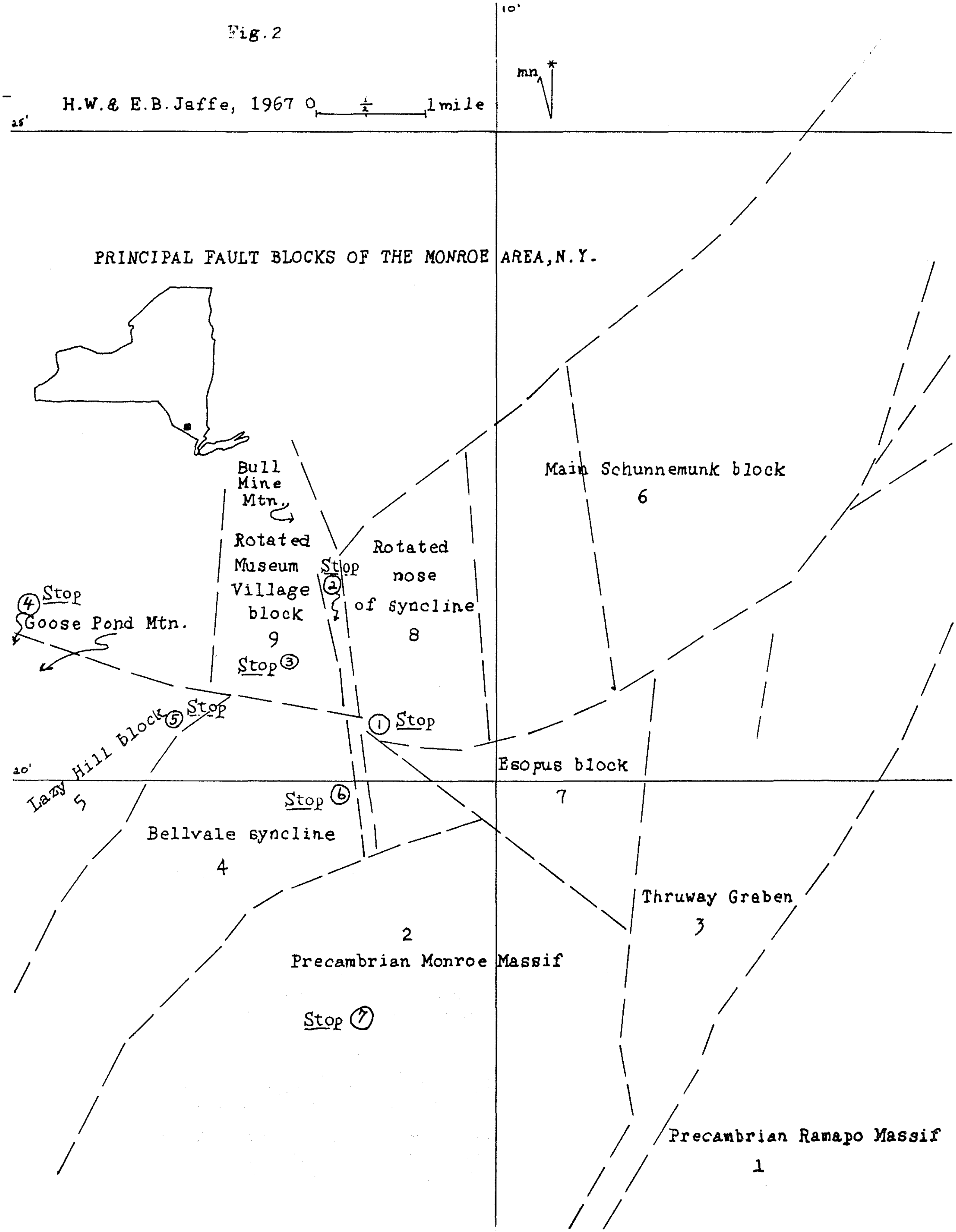


Fig. 1

GEOLOGIC MAP OF THE MONROE AREA, N.Y.

H.W. & E.B. Jaffe, 1967

Fig. 2


H.W. & E.B. Jaffe, 1967
0 ½ 1 mile
10'
mn
25'
20'
PRINCIPAL FAULT BLOCKS OF THE MONROE AREA, N.Y.
Bull Mine Mtn.
Rotated Museum Village block
9
Stop ③
Stop ②
Rotated nose of syncline
8
Main Schunnemunk block
6
④ Stop
Goose Pond Mtn.
Lazy Hill block ⑤ Stop
5
① Stop
Esopus block
7
Stop ⑥
Bellvale syncline
4
Thruway Graben
3
2
Precambrian Monroe Massif
Stop ⑦
Precambrian Ramapo Massif
1

or black (manganese oxide dendrites) with some greens contributed by lichens.

The pebbles, obviously well-rounded when deposited on the Late Ordovician erosion surface, have taken on a secondary angularity and elongation due to stretching, crowding, rotation, and slippage in bedding planes produced during Paleozoic orogenies. Most of the pebbles show maximum elongation parallel to the fold axis (b-direction) and modest elongation parallel to the bedding (a-fabric axis). Many of the pebbles have been corrugated and a large number are cracked and sliced parallel to the b-c fabric plane. Bedding surfaces are slickensided, fluted, and warped parallel to the a-axis (down-dip). The fine-grained, gray-green interbedded quartzite is composed of quartz and minor orthoclase cemented by authigenic quartz, muscovite and chlorite, and Fe-oxides.

The elongation and shattering of the pebbles here and at Lazy Hill to the southwest greatly exceeds that observed in pebble beds in Lower and Middle Devonian rocks (Connelly conglomerate of Oriskany age, and Bellvale graywacke, respectively) in this area, suggesting that the Shawangunk was involved in an additional deformation episode of possible pre-Oriskany age. A pre-Acadian, Silurian deformation period in New York was reported by Megathlin (1939) and discussed by Kay (1942). The sporadic outcrops of Shawangunk quartzite to the north along the western limb of the Schunemunk Mountain syncline are all heavily silicified and sheared, again much more so than quartzites of Oriskany and Bellvale age.

The conglomerate and quartzite outcrop is S-shaped, with the attitudes of the bedding and a cross-fault as follows:

	Strike	Dip
Bedding, Cgl., North end of hill	N 8 E	77 E
Bedding, Cgl., North center of hill	N 59 W	70 NE
Bedding, Cgl., Center of hill	N 27 W	50 NE
Cross-fault	N 77 W	90
Bedding, Qtz., South end of hill	N 2 W	60 E

The cross-fault displaces the stratigraphically higher Shawangunk quartzite member to the west, putting it on strike with the lower conglomerate member of the Shawangunk Formation. On first viewing the outcrop, the alternating coarse pebble beds and fine feldspathic quartzites lead one to suspect that the beds are overturned. On close inspection this does not appear to be the case.

MILEAGE

Return south on N.Y. 208 for 0.5 miles turning right at the first paved road (Museum Village Road). After 0.5 miles turn right on Old Mansion Road and drive to the far west edge of the outcrop on the right.

21.7 <u>STOP 3</u>: <u>Museum Village Klippe: Allochthonous Pre-Cambrian Leucogneiss Resting On Cambro-Ordovician Wappinger Dolomite</u>

From the Old Mansion Road cut in the Precambrian Museum Village klippe, look south across the N 75^{o}W-trending Quickway cross-fault. The ridge due south is the Bellvale synclinal extension of

Schunemunk Mountain. The next ridge to the west is Lazy Hill, held up by Shawangunk conglomerate, and offset from the Golf Range Shawangunk conglomerate of Stop 2. To the west of Lazy Hill, the next prominent ridge is the Goose Pond Precambrian klippe, formerly continuous with the Museum Village klippe and now offset about 2 miles along the Quickway cross-fault.

Museum Village klippe is a thin, synclinal, saucer-shaped slice of gray-white albite-quartz-microperthite leucogneiss that has survived five or six orogenies. The rocks of the allochthon were deposited as a clastic wedge (molasse) in a reducing environment, perhaps as long ago as 1500 million years; they were folded and metamorphosed to the sillimanite-almandine-orthoclase metamorphic grade about 1100 million years ago; thrust from the east in Taconic or Late Ordovician time; refolded and faulted in Taconic time; possibly again in Acadian time; refolded and faulted in Appalachian time; and finally shattered by Triassic block faulting and associated block rotation. In outcrop, the leucogneiss is heavily shattered and slickensided with lineations often running in three directions at a given place. Quartz grains and pebbles are stretched into thin corrugated tongues and sheets showing elongations of 15:1 and 20:1 parallel to the b- and a- fabric axes. Over most of the outcrop, biotite and garnet are extensively retrograded to chlorite, and abundant calcite veinlets cross the rocks at all angles.

Towards the central and western part of the cut there occur occasional thin layers rich in fresh biotite and uncommonly coarse laths (not needles) of fresh blue-gray sillimanite that have survived the complex orogenic history. As none of the Cambro-Ordovician or younger rocks in the area show any metamorphic grade higher than chlorite zone metamorphism, the sillimanite is assumed Precambrian in age, and its preservation in large fresh grains in an otherwise extensively retrograded outcrop is remarkable.

The original sedimentary record of Precambrian deposition is preserved in graphite-rich quartzitic layers and in microscopic placer layers rich in apatite, zircon, sphene and ilmenite. In places, volcanic rocks associated with the sediments may be represented by amphibolites such as those in the Bull Mine Mountain klippe to the north.

Modal analyses of samples collected along an east-west traverse across the Museum Village klippe follows:

Mineral	East Side	Center		West Side
Sample No.	36	769-Si	769-N	769-W
Microperthite	49.5%	37.0%	22.5%	68.8%
Albite (An 0-5)	20.2	–	–	3.3
Andesine (An 32)	–	36.0	32.4	–
Quartz	22.2	2.0	35.1	21.5
Chlorite	5.8	-	-	2.5
Biotite	-	8.0	6.0	-
Almandine-pyrope	0.1	2.0	-	-
Graphite	-	3.0	-	-
Sericite	0.7	-	0.3	-
Sillimanite	-	12.0	3.7	-

Tourmaline	-	+	+	-
Calcite	+	-	-	3.4
Apatite	0.7	+	+	+
Zircon	0.1	-	-	+
Ilmenite	0.7	+	+	+
Pyrite	+	+	-	0.5
Sphene	+	-	-	+
	100.0%	100.0%	100.0%	100.0%

The presence of albite in the most retrograded gneisses of this and the other allochthonous Precambrian blocks studied fairly consistently suggests that it may be a retrograded mineral after an originally more calcic plagioclase. The K-feldspar in all of these rocks is microperthite (usually microcline microperthite) and is indicative of a temperature of Precambrian metamorphism of the order of 660° C. The presence of two plagioclases, one as free grains and the other exsolved in microcline microperthite, is characteristic of many of the granitic gneisses of both the autochthon and the allochthons. In some of the allochthonous leucogneisses, the microperthite and the albite tend to occur in separate bands which may reflect original compositional differences.

Park on Oxford Road and cautiously descend hill to the Quickway (N.Y. 17-West=U.S. 6). Beware of high speed traffic and stay close to the outcrop which parallels the highway. Walk to the extreme west edge of the roadcut where the Precambrian leucogneiss rests in overthrust contact on the light gray Cambro-Ordovician Wappinger dolomite. Note the occasional flat-lying, slippery fracture planes at the contact.

The metamorphic layering in the allochthon dips to the east whereas the dolomite bedding dips predominantly west.

The average foliation of the leucogneiss is N 33 E, 20 SE. The average attitude of the dolomite beds is N 22 W, 35 W. Prominent faults in the klippe parallel the metamorphic layering and trend N 22, E 20 SE. The fault contact of the dolomite and the klippe is irregular and has the same general attitude. Both the dolomite and the klippe are cut by vertical faults trending N 27 W.

MILEAGE

Drive west along Old Mansion Road observing the flat topography superposed on the Hudson River pelites. These are more gently folded with increasing distance from the Precambrian allochthone.

22.7 After one mile, turn right on to Oxford Road at a T-intersection.

23.2 After 0.5 miles turn hard left on to Greycourt Road.

24.4 After 1.25 miles bear left across railroad bridge and continue straight ahead for about 1 mile to Quickway overpass.

26.1 Cross the Quickway (N.Y. 17) overpass and bear hard left (east) on N.Y. 17-M. Drive about 1.1 miles east noting rolling folds in the Hudson River pelites. Road parallels Quickway fault.

27.5 Pull off route 17-M just west of the ridge of Goose Pond Mountain (Goose Pond west).

STOP 4: Goose Pond Mountain: Precambrian Allochthon Over Overturned Hudson River Pelite.

Observe black, fissile Hudson River shales (Middle? Ordovician) in the road cut at the northwest edge of the Precambrian allochthon. Careful observation will show that the attitude of the bedding and cleavage is N 78 E; the bedding dips 70 S and the cleavage 40 S. This indicates that the outcrop is on the limb of an overturned fold with the synclinal axis to the north. The shales both here and at Bull Mine Mountain klippe to the north are all wildly folded and overturned close to the overriding Precambrian allochthons.

Many of the Hudson River black shales are calcareous, and consist of fine laminae (.05-.1mm) of dolomitic silt or mud (marl) intercalated rhythmically (occasionally cross-bedded) with carbonaceous shale. An estimated thin-section mode of a representative Hudson River "shale" follows:

Mineral	Calcareous laminae	Carbonaceous laminae
Detritals and matrix:		
dolomite, calcite	30%	5%
quartz	45	25
plagioclase, microcline	10	+
mica, clay, chlorite	15	50
carbonaceous matter, graphite	-	15
pyrite	-	+
Metamorphic:		
chlorite, muscovite, biotite	-	5
	100%	100%

MILEAGE

In the woods about 100-150 feet southwest of the shale outcrop on N.Y. 17-M, moss-covered rubble of shale, dolomite, and "limonitized" fault breccia indicate where the covered contact has been crossed. The edge of the Precambrian allochthon of Goose Pond Mountain is found in place about 130 feet south from the road, and the first rock found in place is a graphitic calcareous quartzite of which sample No. 527 is representative.

27.9 Drive 0.4 mi. on N.Y. 17-M, stopping at a white albite-quartz-microcline microperthite leucogneiss (sample No. 20), in places graphitic, biotitic or rarely, garnetiferous. Note the extreme elongation and smearing out of quartz pebbles and grains similar to that seen at the Museum Village outcrop of Stop 3. Further to the east, the rocks become increasingly calcareous (sample No. 788). At the extreme eastern edge, prehnitized calc-silicate leucogneiss is interlayered with some amphibolite, the latter of probable basic volcanic origin. Modes of representative rock types of the Goose Pond allochthon follow:

Modes Of Gneisses Of The Goose Pond Mountain Allochthon

	East Side	Center		West Side
Sample No.	529	788	20	527
Mineral				
microperthite	- %	10.0%	42.2%	2.6%
albite (An 0-5)	65.6	-	27.7	-
oligoclase (An 20)	-	49.0	-	-
quartz	16.8	5.0	29.0	81.7
biotite	-	2.5	-	-
chlorite	1.7	-	-	0.3
sericite	7.2	-	0.8	-
graphite	-	-	+	4.2
actinolite	0.2	-	-	3.0
brown hornblende	0.2	33.0	-	-
diopside	1.3	+	-	8.0
sphene	-	-	-	0.2
apatite	+	0.3	0.1	+
ilmenite	-	0.2	0.2	-
prehnite	7.0	-	-	-
zircon	+	+	+	+
	100.0%	100.0%	100.0%	100.0%

Here, as in the Museum Village klippe of Stop 2, the greatest amount of retrograding occurs at the eastern and western margins of the allochthon with some fresh rock occurring near the center. If the klippen are indeed synclinal saucers the presently exposed centers of the masses would lie at a further distance from the sole of the thrust and would be expected to show less alteration. It should be emphasized that the Precambrian autochthonous gneisses in the southern part of the Monroe quadrangle (Jaffe and Jaffe, 1962) are not comparably retrograded except near the Triassic border faults.

MILEAGE

Continue east on N.Y. 17-M about 1.6 miles.

29.5 Turn right (south) on Bull Mill Road for 0.2 miles.

29.7 Turn right at dirt road and park.

STOP 5: Lazy Hill: Shawangunk Quartzite

Walk 0.2 mile west crossing buried northeast-trending fault contact between the Shawangunk ridge of Lazy Hill rising steeply ahead and the Bellvale ridge of Durland Hill to the rear. Walk to the north nose of Lazy Hill (permission of the owners, the Durlands, is necessary) where a large outcrop of Shawangunk quartzite is exposed. The rock is a thin-bedded, pink, buff and white orthoquartzite consisting of:

Mode Of Shawangunk Orthoquartzite, Durland Property

Quartz	93%
Chert	5
Sericite, Chlorite	2
Zircon	+
Hematite	+
Goethite	+
Pyrite	+
Green tourmaline	+
	100%

The quartz grains are well-rounded, moderately elongated, well-sorted (average diameter, 0.75mm), and the rock is very tightly cemented. Each grain of quartz is cemented to another by authigenic quartz overgrown in optical continuity with the detrital cores. Undulatory extinction due to deformation passes through both the core and overgrowth of each grain. The Lazy Hill ridge-top to the south (not visited) is formed of a coarse white pebble conglomerate interbedded with white orthoquartzite (occasionally ripple-marked) and grades eastward to a red arkosic conglomerate below the ridge-top. Quartz pebbles and orthoclase pebbles are strongly elongated (3:1 and 4:1) and heavily shattered and veined in both the red arkosic and the white conglomerate.

MILEAGE

29.9 Return to N.Y. 17-M and turn right (south).

32.0 Drive south about 2.0 miles to the Monroe Bowl-O-Fun parking lot.

STOP 6: Monroe Bowl-O-Fun: Connelly (Oriskany) - Esopus Contact

The outcrop at Monroe Bowl-O-Fun consists of about 300 feet of the Esopus Formation underlain at the rear of the cut by red and white pebble conglomerate, the Connelly Conglomerate of Oriskany age. Here, the Connelly consists of weathered, yellow, "limonitic" conglomerate (3' or more), succeeded by white to buff, pebble-bearing orthoquartzite (5'), which is in turn overlain by bright red hematitic quartzite (10'). The pebbles in the Connelly conglomerate are of white, round to slightly elongated quartz, averaging 1-2mm in maximum dimension. The Connelly is disconformably overlain by a lowermost member of the Esopus Formation, recognized by Southard (1960). The attitude of the bedding of both the Connelly and the Esopus at their contact is N 68 E, 45 N. A heavily slickensided fault surface, trending N 53 E, 60SE cuts across the Connelly beds and presumably also cuts the overlying Esopus Formation.

The lowermost member of the Esopus, at its base, consists of fissile, blue-gray siltstones which weather to brown and orange on cleavage surfaces. Many of the rocks are marked with _Taonurus cauda-galli_ on bedding planes. At this outcrop the authors have collected a remarkable fauna including a specimen of the giant trilobite, _Coronura myrmecophorus_, not previously reported from the Esopus Formation. According to D.W. Fisher, New York State Paleontologist who identified the specimen, it has previously been reported from the Schoharie and Onondaga Formations. The specimen was donated to the N.Y. State Museum collection.

The lowermost member is also relatively rich in conulariids, none of which have yet been identified. Other fauna include the brachiopods: _Leptocaelia flabellites_, _Schuchertella sp_, _Acrospirifer macrothyris_, as well as some chonetid and orbiculoid genera. Platyostomid and loxonemid gastropods, rugose corals and a dalmanited trilobite were also collected by the authors.

The lowermost member grades into the black, poorly fossiliferous Lower Mudstone member which in turn grades into a purple sandstone at the north end of the 350 foot exposure. The sandstone is presumably the lower part of the Highland Mills member of the Esopus Formation. The fauna of the lowermost member at the Bowl-O-Fun appears to differ significantly from that of the Highland Mills member of the Esopus Formation found at Bakertown and Highland Mills (described by Boucot, 1959). The fauna should receive some serious study by specialists before the outcrop is demolished by new construction.

MILEAGE

32.7 Drive 0.7 miles south on N.Y. 17-M to the second traffic light.

34.1 Turn right at light on to Stage Road which becomes the Orange Turnpike and continue south for 1.4 miles. Park along the roadside before reaching a house on the right side.

STOP 7: Orange Turnpike: Poughquag Quartzite (Lower Cambrian)

Walk 0.16 miles due west over hilltop to the edge of a cliff formed by a 10 foot section of the Poughquag Formation (Lower Cambrian). The section consists of alternating 2 inch to 2 foot thick beds of ferruginous orthoquartzite, conglomerate, and arkose, striking N 75 W and dipping 8°N, overlying the vertically dipping Precambrian autochthon with marked angular unconformity. This represents original sedimentary onlap with only gentle warping or folding in subsequent geologic time.

Apparently the Precambrian Monroe Massif (Block 2) was sufficiently rigid throughout the Paleozoic to prevent the deformation of the overlapping embayment of Poughquag quartzite and Wappinger dolomite. This is indicated by both the gentle warping observed and also by the relative sphericity of the quartz pebbles in various Poughquag beds.

Several of the beds are feldspathic, a feature uncommon in the Poughquag of the Poughkeepsie quadrangle (Gordon, 1911). One such bed at the Monroe outcrop is a conglomeratic arkose which is a true high rank arkose in the sense of Krynine (1948). A remarkable textural feature of this rock is the abundance of authigenic feldspar (microcline?) which is the principal cementing medium in sample No. 466. The specimen consists of 1-2mm quartz and microcline pebbles (all very round) lying in a matrix of 0.2mm grains of microcline and much less quartz. The microcline grains, each with a dirty outline (Fe and Mn oxides), tend to float in the matrix of authigenic microcline (?) cement which is clear in appearance. Some sawtooth or hacksaw terminations on the detrital microcline cores (Edelman and Doeglas, 1931) indicate that interstratal solution has taken place after deposition, presumably <u>in situ</u>. The authigenic feldspar overgrowths show only weak twinning when grown around detrital cores showing strongly developed microcline twinning. A mode of such rock is as follows:

Mode Of Lower Cambrian Poughquag Conglomerate Arkose
Specimen No. 466

Microcline	47.4%
Microcline microperthite	+
Quartz	48.6
Albite-oligoclase	+
Muscovite	+
Rutile, Anatase, Tourmaline (green + brown)	0.5
Zircon	0.5
Hematite Mn oxides	3.0
	100.0%

The mineralogical composition of the Poughquag at Monroe leaves little doubt that it was derived from erosion of the granitic gneisses it overlies.

On the return walk to the road, stops may be made at exposures of post-Wappinger lamprophyre dikes which the authors believe to be of Late Ordovician age (Jaffe and Jaffee 1962). The authors have studied the dikes in considerable detail and would suggest a possible age of intrusion similar to that of the ultramafic intrusion of the Cortland Complex at Stony Point, New York (Ratcliffe, 1967). The Cortland Complex has been dated by Long and Kulp (1962) at 435 million years by K/A isotopic ratios obtained on biotite from the complex, a date close to the accepted Ordovician-Silurian boundary.

Return to NYSGA Field Headquarters at the Holiday Inn, Newburgh: north on Orange Turnpike and Rte. 208 to N.Y. 17-Quickway; west on Quickway to N.Y. Thruway Harriman Exit-16; north on N.Y. Thruway to Newburgh Exit-17 and Holiday Inn.

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ROAD LOG TRIP G*

Leader: G. Gordon Connally

TOTAL MILES	Miles from last stop	
00.0	0.0	Assembly Point: The west parking lot, Holiday Inn, Route 17M Newburgh, New York, near Thruway Exit 17.
		Departure Time: 8:15 a.m. Travel will be by car caravan — cars will form after the buses for the other trips have cleared the area.
		Leave Holiday Inn and turn left (east) on Route 17K.
00.2	0.2	STOP G-1. Examine the ablation till exposed in the cut behind the Carrol's stand. Compare this till to the lodgement till exposed at Stop A-2 on trip A. There will be a discussion of weathering profile and soil development.
		Turn right (west) on Route 17K and proceed back toward the Holiday Inn.
00.4	0.2	Pass the Holiday Inn on the right.
01.4	1.2	Stewart Air Force Base is on the left.
03.1	2.9	Turn right (north) on Rock Cut Road.
04.3	4.1	Turn left (west) onto Route 52 at the Stop Sign.
05.3	5.1	Bear right (north) on St. Andrews Road.
05.5	5.3	Cross the Catskill Aqueduct. The aqueduct follows the road on the right for 1/2 mile until it is re-crossed. After re-crossing the aqueduct note the lithology of the stone walls, particularly the absence of Shawangunk boulders.
07.2	7.0	Continue straight at the Stop Sign at the village of St. Andrews.
07.4	7.2	Ascend the till ridge that trends north-south. This is a ridge of drumlinized crests that can be traced for about 10 miles east of the Wallkill Moraines.
07.6	7.4	Railroad Crossing!
07.8	7.6	Bear right (straight) onto Hoyt Road. This road traverses a flat-topped outwash deposit that has a 400 foot crest on the distal side of the Wallkill moraines. This suggests that the ice occupied the Wallkill position during the development of the 400 foot lake level.
08.3	8.1	Ascend the gentle distal slope of the outermost Wallkill Moraine and then descend the proximal slope into the stagnant ice complex.

* For text see Article p. A1 — A21.

TOTAL MILES	Miles from last stop	
09.1	8.9	Cross the first inner Wallkill Moraine.
09.3	9.1	STOP G-2. Here can be seen some of the Wallkill Moraines. Their possible relationships and the relation of the Wallkill River to the glacial deposits will be discussed.
		Continue north on Hoyt Road.
10.0	0.7	Bear left.
10.4	1.1	Turn right (east) onto Route 208 at the Wallkill Central School. The Wallkill Moraines are well displayed on the right.
12.2	2.9	Cross the distal slope of the second inner Wallkill Moraine. This moraine is on a bedrock escarpment and is not nearly as massive as the topography makes it appear. The State Prison Moraine (?) is on the left in the distance.
13.9	4.6	Cross the Catskill Aqueduct.
14.8	5.5	A striated bedrock knob is exposed on the right.
15.6	6.3	The State Prison Moraine (?) is immediately adjacent to the road on the left and will be crossed in the vicinity of Ireland Corners.
16.3	7.0	Continue straight at the Ireland Corners traffic light.
19.6	10.3	On a clear day a splendid panorama can be viewed on the left. In the foreground is the Lower Wallkill Valley with the Shawangunk Mountain cuesta in the distance. The Catskill Mountains can also be observed on the skyline behind, and north of, the Shawangunks.
20.5	11.2	Turn left (west) on Cedar Lane.
20.8	11.5	Turn right (north) on Plains Road.
21.5	12.2	STOP G-3. Leave the cars and walk through the field on the left to the sand pit. Examine the relationship between proglacial lakes, deglaciation, and the present course of the Wallkill River. This deposit is the remnant of a delta formed in the final 230 foot lake in the Wallkill Valley.
		Continue north on Plains Road.
21.9	0.4	The Wallkill River is on the left.
22.0	0.5	Railroad Crossing!
22.2	0.7	Bear left on Water Street.
22.3	0.8	Railroad Crossing!
22.4	0.9	Cross Main Street and continue north on Huguenot Street. The floodplain of the Wallkill River can be seen on the left. The floodplain evidently extends only to the low

TOTAL MILES	Miles from last stop	
		escarpment a few hundred feet west of the River with undisected lake plain from the scarp to the west valley wall.
22.7	1.2	Stay left on Huguenot Street. This street contains the old stone houses for which New Paltz is famous. These stone houses were built by the Huguenots in the late 1600's and early 1700's.
22.9	1.4	As the road bends right and then left it is following an abandoned meander of the Wallkill that now exists as an Oxbow Lake. This oxbow may be seen behind the houses to the left.
23.7	2.2	Railroad Crossing!
23.8	2.3	Stay left on the Old Kingston Road.
24.2	2.7	Turn right (east) on Shivertown Road.
24.3	2.8	Turn left (north) on Route 32. From this point to Stop G-4 Route 32 follows the shoreline of the 230 foot lake. This may explain the frequently exposed bedrock along the east side of the road.
27.7	6.2	Route 213 joins from the right just south of the bridge over the Wallkill River. Note that the Wallkill is cutting a bedrock channel to the right while flowing over lake sediment on the left.
27.9	6.4	STOP G-4. Here will be discussed the geomorphology of the Wallkill River drainage basin and its relation to the Rosendale sand plain.
		Continue north on Route 32.
28.4	0.5	Descend from 240' on the sand plain to 65' in the Rondout Creek Valley.
29.2	1.3	Bridge across Rondout Creek. Note the channel bars in the creek; these did not exist before the recent drought.
31.2	3.3	Pass over the New York State Thruway.
31.8	3.9	Cross a remnant of the 200 foot Lake Albany (?) plain.
32.8	4.9	Turn right (east) on Dewitt Lake Road.
33.5	5.6	Bear left on Mountain Road and parallel the Fly Mountain fault scarp.
34.3	6.4	Route 213 joins from the right and the road is adjacent to Rondout Creek.
34.8	6.9	STOP G-5. This is the Wilbur gravel pit of the City of Kingston. It is the type locality for the Wilbur limestone member of the Rondout Formation (Silurian). Leave the cars on the road and walk up into the pit to examine the relationship between the ice-contact gravels and the slumped, overlying Lake Albany (?) sands, silts,

TOTAL MILES	Miles from last stop	
		and clays. Examine the pebble lithologies and compare them with those at Stops A-1, A-6, and A-8 on Trip A.
		Continue north on Route 213.
35.4	0.8	Turn left (north) on Dunn Street, following Route 213.
35.5	0.9	Turn left (west) on Wilbur Avenue, following Route 213.
36.7	2.1	Continue straight on Route 213 at the Stop Sign.
36.8	2.2	Turn right at the first Stop Sign and then right again at the second Stop Sign and follow Henry Street to the north.
37.0	2.4	Continue straight at the traffic light.
37.3	2.7	Turn left (north) at the traffic light and proceed on Route 32-28.
37.6	3.0	Continue straight at the traffic light and join Interstate 587.
38.8	4.2	Bear right and continue 1/8 turn at the circle. At this point those cars going north or those picking up passengers in Newburgh may get on the New York Thruway. Other cars going south at a more leisurely pace may take an alternate route not contained in the roadlog and may visit some karst features in the Rondout Valley before proceeding south or west.
38.9	4.3	Bear right on the Thruway - stay left for New York-New Jersey.
47.1	12.5	Lake Albany (?) clays crop out on both sides of the Thruway.
47.5	12.9	Cross Rondout Creek cutting a bedrock channel at this point.
50.0	15.4	Cross Wallkill River cutting bedrock channel at this point.
55.9	21.3	Exit 18 for New Paltz.
71.8	37.2	Bear right at EXIT 17 for Newburgh.
72.6	38.0	Stay left to Route 17K.
72.8	38.2	Bear right toward Route 17K (Middletown).
73.0	38.4	Join Route 17K proceeding west.
73.1	38.5	Continue straight at the traffic light.
73.3	38.7	Arrive at the Holiday Inn, Newburgh, New York.

Your turn now Walt!

ROAD LOG FIELD TRIP H

Co-leaders: Russell H. Waines and Florence Grosvenor Hoar

TOTAL MILES	Miles Between Points	Remarks
0.0	0.0	Holiday Inn parking lot. Exit, turning left (east) onto NY 17K. Proceed to New Paltz, New York, via NYS Thruway as directed in Road Log for Field Trip D (p. D17).
16.9	16.9	Bear right for NYS Thruway Exit 18 (New Paltz) and proceed past toll booth (north).
17.5	0.6	Fork. Bear left and proceed to stop sign. Turn left (west) onto NY 299 and cross over NYS Thruway.
18.6	1.1	Traffic light. NY 32 south on left. Continue straight on NY 299.
18.8	0.2	Turn left (north) downhill onto NY 32.
18.9	0.1	Stop Sign. Turn right onto NY 32 and proceed north. Outcrops and road cuts for the next 4.8 miles expose Ordovician shales and siltstones of Snake Hill (?) aspect. Remarks concerning the Ordovician strata north and south of New Paltz in the Road Log for Field Trip D (p. D17) also apply to this trip.
21.9	3.0	Clearwater Road on the left. Road cuts in the Ordovician shales on this road have produced a small fauna of Snake Hill (and equivalent) aspect.
23.6	1.7	Bridge over Wallkill River.
25.5	1.9	Park opposite extensive road cut on right (east) at bottom of long hill.
		<u>STOP 10: (numbered from sequence in Trip D) Rosendale; Rosendale Dolomite (part), Binnewater Sandstone, High Falls Shale and Shawangunk Conglomerate (part) Sequence:</u> Examine the almost continuous exposure of northwest-dipping strata. The sequence consists of a few feet of Rosendale Dolomite (north) overlying a completely exposed section of Binnewater Sandstone which in turn overlies a partly covered section of High Falls Shale overlying an exposure of several feet of Shawangunk Conglomerate (south). The total thickness of the conglomerate is not known at this point. The Rosendale-Binnewater-High Falls-Shawangunk contacts are all well-exposed and worth noting.
		Return to transportation and continue north on NY 32.
31.1	0.6	Bridge over Rondout Creek. Turn left road just past bridge. Stop before turning left onto NY 213. Proceed west on NY 213 through the Village of Rosendale.

TOTAL MILES	Miles Between Points	
31.9	0.8	Pass under New York Central railroad trestle.
32.0	0.1	Turn sharp right uphill onto Binnewater Road and proceed north.
32.4	0.4	Century Cement Company natural cement kilns on left; still in occasional operation.
33.0	0.6	Keators Corner (Binnewater). Continue straight north on Binnewater Road.
33.3	0.3	Leave Binnewater Road by keeping straight (north) into entrance to Williams Lake Hotel grounds.
33.4	0.1	Keep straight.
33.5	0.1	Turn right across railroad track into private turning area. Park, taking care not to block access; walk back to railroad, turn right (north) and proceed to nearby railroad cuts.
		STOP 7: For description of this stop refer to stop of same number in Road Log for Trip D (p. D23).
		Continue walking north along track toward Stops 11 and 6.
33.75	0.25	Extensive exposure of High Falls Shale continues for about 0.1 miles on right (east).
33.9	0.15	Dirt road crossing track.
34.0	0.1	Railroad cuts along track for next 0.15 miles.
		STOP 11: Fourth Lake (South); Kalkberg, Coeymans, Thacher, Rondout, Binnewater (part) Sequence: Examine the easterly-dipping sequence of strata on the east side of the track. (Because the exposures on the west side are fault-complexed they are not considered here). Beginning with the Binnewater Sandstone (south) a more or less regular sequence follows: Binnewater Sandstone (Are there Fossils in the upper Part?); Rondout Formation (Are all the members recognizable? Note the mine in the Rosendale Dolomite.); Thacher Limestone (Is a complete section present?); Ravena Limestone (Where is the Thacher - Ravena contact? Is it disconformable?); and Kalkberg Limestone (Hannacroix Member) (Where is the Ravena - Kalkberg contact? Is *Gypidula coeymanensis* present?).
		Continue walking north to northeast another 0.05 miles along track. Fourth Lake is on the left.
34.3	0.2	For the next 0.2 miles a continuous sequence is exposed on the left (west) which descends stratigraphically from lower Thacher Limestone through Ordovician shale.

TOTAL MILES	Miles Between Points	
		STOP 6: For description of this stop refer to stop of same number in Road Log for Trip D (p. D 22). The sequence is now in reverse order. When inspection of the section is completed find path on the right (east) which leads over waste rock dump and downhill over glaciated outcrop of Ordovician shale ending in front of abandoned natural cement kilns. Time permitting, the kilns can be inspected, a nearby cement mine visited and a lower Thacher Limestone rock pile searched for fossils and sedimentary structures.
		Board waiting transportation and drive to eastern exit (to the northeast) of large open field.
34.6	0.3	Exit right (south) from open field onto Hickory Bush Road and proceed south.
35.3	0.7	Junction with Breezy Hill Road on right. Keep straight on Hickory Bush Road.
35.6	0.3	Kallops Corners. Turn right (south) onto Old NY 32 and proceed south.
36.1	0.5	Stop Sign. Bear left and proceed south on NY 32.
36.7	0.6	Bridge over Rondout Creek. Retrace original route to this point via NY 32 south to New Paltz and then by NYS Thruway south to Holiday Inn, Newburgh, near Exit 17 NYS Thruway.
67.8	31.1	Holiday Inn parking lot.

ABSTRACTS

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GENESIS OF CARBONATE CONCRETIONS IN THE MIDDLE DEVONIAN UPPER LUDLOWVILLE FORMATION, ERIE COUNTY, NEW YORK

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ABSTRACT

Concretions in a zone about twelve feet below the Tichenor Limestone (uppermost member of the Ludlowville Formation) formed when just below a sediment-water interface. Their growth proceeded downward and laterally from an organic-rich center and was completed before they were more than five to ten feet below the sediment surface. Chemical products of organic decay, notably ammonia, diffused outward and reacted with connate waters, saturated with respect to calcite, raising the pH and precipitating calcite. First, these conclusions derive from the shape of the concretions, from their relation to the enclosing shales, and from their overall structure, particularly the position of pyritic fossil layers. Second, the relative volumes of soluble material (calcite) in the concretions are comparable with the relative pore volumes through the upper 10 feet of recent, fine-grained, clayey sediments. Finally, the postulated genetic sequence agrees with recent work on carbonate diagenesis. The formation of concretions was restricted to discrete zones by widespread combinations (of limited duration) of the rates of sedimentation, water circulation, and organic productivity, favorable to the rapid burial of much undecomposed organic material.

HYDROLOGY OF THE CAVERNOUS LIMESTONES OF SCHOHARIE & ALBANY COUNTIES, NEW YORK

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ABSTRACT

In a study conducted as part of a special topics course in Karst Hydrology, the author has investigated anomalous hydrologic conditions in the limestone uplands of the Allegheny Front where it intersects Albany and Schoharie Counties. A detailed study was made of the Upper Silurian and Lower Devonian carbonates and their water-bearing properties. The results of this study were combined with quantitative discharge measurements on springs and disappearing streams, and also with quantitative data from time of travel studies utilizing Rhodamine B, a fluorescent dye.

It was found that the thin-bedded, closely jointed Manlius Limestone (joint spacing one to five feet) formed cavernous openings acting as conduits for seasonally varying discharges. Protected by the massive, thickly bedded, overlying Coeymans Limestone, these conduits in the Manlius have been observed to discharge as much as 35 cubic feet per second at the Doc Shaul's Spring Gaging Site. The time of travel studies provided for injection of a dye into a disappearing stream and for measurement of the time required to detect this dye at the resurgence of the underground system. It was found that travel times varied from 40 hours for the two mile run from Thompson's Lake to Pitcher Farm Spring, to only four hours from Skull Cave Sinkhole to Beaverdam Springs. Moreover, travel times varied remarkably with the discharge through the cave system. A travel time of four hours through the Skull Cave System (approximately one mile in length) at discharge 15.1 cfs is to be contrasted with a 25 hour travel time through the same system at 4.1 cfs. Dye studies have also revealed the unusual hydrologic conditions caused by the blocking of pre-Pleistocene cave resurgences by glacial deposits. The result of the latter event has been the flooding of the entire lower portion of a Manlius cave system and the formation of the well-like Doc Shaul's Spring, which is fed by water under a hydrostatic head (very similar to artesian conditions). All results above are combined with data concerning known cavern systems in the area to construct a regional hydrologic picture.

THE ACFM PROJECTION — A POTENTIALLY USEFUL TOOL IN MINERAL EQUILIBRIUM STUDIES

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ABSTRACT

In granulite facies terranes, aluminum-, calcium-, iron-, and magnesium-bearing rocks frequently exhibit equilibrium assemblages containing more than three phases. The ACF triangular diagram in which iron and magnesium are added together in the "F" corner is thus inadequate to represent such assemblages.

By analogy with Thompson's (1957) graphic analysis of pelitic schists, the system SiO_2-Al_2O_3-CaO-FeO-MgO-H_2O may be reduced to an ACFM tetrahedron in the analysis of quartz-bearing rocks provided that H_2O is externally controlled as the humidity. The anorthite molecule is chosen as a point from which to project ACFM compositions onto the CFM plane, resulting in a map of those phases in equilibrium with quartz and anorthite for a particular range of pressure, temperature, and humidity.

Calculating rules for locating compositions on the projection are presented and discussed. Chemical analyses of four Adirondack rocks of gabbroic composition together with analyses of their constituent minerals are plotted on the ACFM projection. The variable Fe/Mg ratios of the rocks is clearly reflected in the Fe/Mg ratios of the phases present. The three-phase area for each assemblage is extremely small. Reasons for this anomaly are discussed and it is suggested that oxygen fugacity may exert a control over the bulk Fe/Mg ratio, shifting phase compositions to more magnesian values.

DISTRIBUTIONAL VARIATIONS OF A BRACKISH—WATER FAUNA IN A CHANGING ENVIRONMENT

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ABSTRACT

Investigation of the ecology and distribution of recent microfauna in the upper estuary of the Rappahannock River of Virginia revealed a facies boundary between the salt water foraminifera of the lower estuary and the fresh water thecamoebinids upstream corresponding to the 0.5 ‰ isohaline. With periods of low rainfall and discharge in the upper river valley, this isohaline shifted upstream, allowing foraminifera to migrate into marches which are normally fresh. Examination of a suite of 3-meter cores from Hunter Marsh near the estuary head (84 km or 52 nautical miles from the mouth) revealed a series of microfaunal population fluctuations at depth between percentages of foraminifera and thecamoebinids in 5-cm slice-samples.

Three explanations are suggested: (1) This data may be an "organic rain gauge" record of environmental changes, especially salinity, which have occurred in the estuary. As rainfall and discharge decrease, the foraminifera migrate upstream with the salt wedge. Return to more normal conditions freshens the marshes and kills the foraminifera; (2) The fluctuations may be a meaningless reflection of normal marsh variability; or (3) Sea level changes and sediment infilling may have modified the estuary. Carbon 14 datings from the base of two cores suggest an average rate of vertical marsh accretion and sea level rise of 0.130 cm per year.

More research is necessary before the most plausible explanation can be determined. If long term droughts are documented, they could help explain the Indian shell heaps of oysters along portions of the Hudson River which are now fresh water.

HEAVY MINERAL SIZE DISTRIBUTION IN SOME ERIE AND WARREN BEACH SANDS, WESTERN NEW YORK

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ABSTRACT

The principal objective of this study was to investigate textural characteristics of individual heavy minerals across beach zones of varying energy on the Lake Erie shore, western New York. A linear series of samples was collected from plunge point to dune. A similar series was also collected for comparative purposes from Lake Warren, a pre-Erie strandline.

Heavy minerals were separated from sand fractions, sieved at 1/2 Ø intervals, mounted, identified, counted, and statistically evaluated quantitatively by weight per cent.

Notable results show that (1) textural parameters of heavy minerals reflect higher environmental sensitivity than corresponding quartz sands, (2) abundance of heavy minerals generally increases inland across the beach, (3) garnet and zircon show particular promise as environmental discriminants, especially with respect to skewness and mean diameter, and (4) under subaqueous conditions, specific gravity chiefly governs the heavy mineral depositional regime whereas in aeolian transport, shape and lack of density combine their influence in controlling heavy mineral behavior.

STRUCTURE AND METAMORPHISM OF HURONIAN ROCKS AT ESPANOLA, ONTARIO

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ABSTRACT

During the Penokean orogeny, pelitic metasediments of the McKim (Nordic) Formation in the vicinity of Espanola, Ontario, suffered polyphase deformation and attendant metamorphism. Intrusion of Nippissing diabases and genesis of Sudbury-type breccia accompanied deformation.

Major folding was accompanied by development of a vertical axial-plane cleavage which strikes east-west. Lineations and minor fold-axes associated with this major deformation plunge both east and west reflecting the attitudes of major folds. Evidence of an earlier deformation is seen in thin-section where a fine foliation, delineated by flakes of sericite, and cross-cutting bedding, is cross-cut by the cleavage associated with major folding. A late phase of deformation produced strain-slip cleavage and minor folds.

Both the Nippissing diabases and the Sudbury-type breccias are transected by cleavages related to the major and late phases of deformation. Thus, in the Espanola area, diabase intrusion and formation of breccia preceded major folding.

Prior to and during the major phase of deformation, metamorphism reached its maximum intensity with the formation of chloritoid and garnet in the pelitic metasediments, and actinolite and hornblende in the diabases. No evidence was found for the presence of metamorphic zones of the type previously described in the Agnew Lake area; rather, the distribution of chloritoid and garnet was found to be controlled by lithology. Chloritoid-bearing members occur as mappable stratigraphic units.

ELECTRICAL RESISTIVITY INVESTIGATIONS OVER LIMESTONE CAVERNS IN EASTERN NEW YORK

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ABSTRACT

Electrical-resistivity prospecting techniques were employed with reasonable success in detecting cave passages by measurements made on the overlying ground surface. Passages were detected in at least nine out of 13 vertical profiles conducted over the cave passages. The results were compared with theoretical relationships expressing apparent resistivity as a function of electrode spacing, passage size and depth, and bedrock resistivity. Two of seven horizontal profiles succeeded in detecting a cave passage; these two profiles agreed well with the results of a model experiment.

The eastern New York field sites where this research was conducted feature an even surface topography underlain by cavernous limestones and dolomites which are flat-lying and electrically-homogeneous. The cavernous formations are overlain by a low-resistivity surface (weathered) layer which tends to screen out electrical effects arising from the cave passages below. Water-table levels had relatively little effect on the resistivity measurements, but large seasonal variations in surface-layer resistivity at one site are reflected by a marked difference in the success of cave detection.

THE PALEOMAGNETISM OF TWO DIABASE DYKES OF THE WHITEFISH FALLS AREA, ONTARIO

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ABSTRACT

Strangway (1961) stated that the stable remanent magnetism in diabase dykes was aligned in the plane of intrusion of the dyke due to demagnetization of the remanent component normal to the intrusive sheet. Fahrig _et_ _al_. (1964) and Sopher (1963), from their studies of diabase dykes, do not support Strangway's proposition.

Eighteen samples were drilled across the width of a large NNW-striking diabase dyke, and thirteen samples along the length of a narrow dyke controlled by a jointing system striking in two predominant directions, N 110° E and N 150° E. The two dykes are assumed to be related to the Sudbury dykes which have been dated at 1285 m.y. (Fahrig _et_ _al_.,1964).

The remanent magnetism of the samples was measured with an astatic magnetometer. The means of the declinations and inclinations of the remanent magnetism for the large and small dyke before demagnetization were determined as 105.5°, + 46.5° and 99.0°, + 20.5° respectively. The remanent vectors from the small dyke did not change in direction with any change in the strike of the dyke itself. The magnetism of both dykes is very homogeneous. The samples were demagnetized in A.C. fields of 50 oe., 100 oe., 150 oe., 200 oe. and 500 oe. r.m.s. From the paleomagnetic data it was concluded that the remanent magnetism of the two diabase dykes was not affected by their plane of intrusion. Paleomagnetic poles were determined to be 2.1° N, 17.8° W for the large dyke, and 1.1°N, 6.4° W for the small dyke.

AN OCCURRENCE OF THE HOLOTHUROID SCLERITE PROTOCAUDINA FROM THE DUNDEE LIMESTONE (LOWER MIDDLE DEVONIAN), SOUTHERN ONTARIO

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ABSTRACT

Only seven occurrences of holothuroid sclerites have been reported from rocks older than Carboniferous. Five species have been reported from the Ordovician (Weiss, 1954; Gutschick, 1954; Reso and Wegner, 1964). Four species have been reported from the Devonian (Prantl, 1947; Martin, 1952; Lehmann, 1958).

The Dundee Limestone is considered lower Middle Devonian and lies between the Hamilton Group and the underlying Detroit River Group. One well-preserved holothuroid sclerite, Protocaudina comparable to P. kansasensis (Hanna), has been found in acetic acid residue from the Dundee. Previously P. kansasensis (Hanna) has been reported only from Permian rocks. The one other reported occurrence of Protocaudina below the Carboniferous is P. hexagonaria Martin from the Upper Middle Devonian Cedar Valley Limestone of Iowa (Martin, 1952).

The fauna associated with the Dundee holothuroid material includes conodonts, ostracods, fish remains and sponge spicules.

POLLUTION VERSUS RECENT FORAMINIFERA IN THE HUDSON RIVER

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ABSTRACT

Four cores approximately 100 centimeters in length were taken of bottom sediments in the Haverstraw Bay - Tappan Zee Bay area of the Hudson River, New York, in the summer of 1964. The sediments contained in the cores are a moderately to poorly sorted mixture of clay, silt and sand of latest post-glacial age. The porportions of silt (62%), clay (32%), and sand (6%) are more or less constant throughout the length of each core. Quartz is the dominant sedimentary particle.

Two distinct assemblage zones are manifest in the foraminifera population of the four cores. The upper or Ammonia beccarii assemblage zone is dominated by Ammonia beccarii and comprises the upper thirty-five centimeters of each core. The lower or Elphidium clavatum assemblage zone comprises the lower sixty-five centimeters of each core. Species of Elphidium are not present in the A. beccarii assemblage zone, although A. beccarii is found in the E. clavatum assemblage zone.

Bulbous, frothy, solid pollutants occur in the upper thirty-five centimeters of each core. The pollutants, first introduced about forty or fifty years ago, are the solid remains of oil sludge pumped from ships in the Hudson River. The coincidence of the break between the Elphidium clavatum assemblage zone and the Ammonia beccarii assemblage zone and the appearance of pollutants, suggests that the pollution had either direct or indirect toxic effects on the species of Elphidium. Ammonia beccarii appears to have survived and flourished under conditions adverse to Elphidium.

STRATIGRAPHY AND STRUCTURE OF THE ROSENDALE AREA, ULSTER COUNTY, NEW YORK

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ABSTRACT

The region considered comprises all but the northwest quarter of an area bounded by latitudes 41° 49' and 41° 51' north and longitudes 74° 04' and 74° 06' west. Bedrock consists of a sequence of clastic and carbonate strata of middle (?) Ordovician, late Silurian, and early Devonian age.

The stratigraphic units observed in the area in descending order are:

FORMATIONS OR MEMBERS	APPROXIMATE THICKNESS IN FEET
Lower Devonian	
Esopus shale	(?)
Glenerie limestone	(?)
Connelly sandstone	5 - 10
Port Ewen shaley limestone	110
Alsen limestone	15
Becraft limestone	55
New Scotland shaley limestone	135
Kalkberg limestone	40
Coeymans (Ravena) limestone	20
Manlius (Thacher) limestone	45
Upper Silurian	
Whiteport dolomite	13
Glasco limestone	15
Rosendale Dolomite	20
Binnewater sandstone	30
High Falls shale	50
Shawangunk conglomerate	5 - 250 plus
Middle (?) Ordovician	
Martinsburg or Snake Hill shales and slates	Unknown (possibly several thousand)

The region has apparently been affected by two periods of deformation but deformation of Ordovician strata resulting from the Taconian orogeny is largely masked by subsequent Appalachian folding and faulting. The present structure commonly involves east-dipping thrust faults of moderate to low angle and open to close folds with infrequent overturning of limbs. Through much of the region major faults appear to remain separate and parallel to one another. On occasion they appear to truncate folds and to the northwest they seem to pass into folds or to die out. Foreshortening due to faulting and folding is estimated at a ratio of one to four. Folds tend to plunge to the northeast; in the northwest they tend to die out.

Understanding of structure in areas with close Silurian and Devonian stratigraphic control may be helpful in determining structure in adjacent areas underlain solely by Ordovician sediments with poor stratigraphic control.

PLEISTOCENE GEOLOGY OF SOUTH—CENTRAL AND SOUTHWESTERN VERMONT

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ABSTRACT

Southern Vermont shows strong evidence of glaciation by a continental ice sheet moving across the area from north 10° to north 40° west at its maximum. This direction of movement is inferred from striations, boulder distribution, and till fabric. As the ice retreated to a position north of the Massachusetts border, Glacial Lake Hoosic, with its water plane at 1100 feet and its outlet at Pittsfield, Massachusetts, was formed in the valley of the Hoosic River. Vestiges of this lake in Vermont are deltas and beach deposits in Stamford, southeast of Pownal, and on the south-west flank of Mount Anthony. Patches of lacustrine clay occur along the Hoosic River.

Lobes of ice existed in the Vermont Valley, Hudson Valley, and Connecticut Valley during deglaciation, during a readvance, or as a result of the ice of a separate glacial stage spreading into southern Vermont. The lobes in the Hudson and Vermont Valleys were contemporaneous as ice must have been present in New York to form a dam for high-level, ice-marginal lakes in the Vermont Valley. The temporal relation of these lobes to a possible Connecticut Valley lobe is not obvious.

Boulder trains, striations, till fabric and distinct, cross-valley kame and till moraines indicate that the ice lobe in the Vermont Valley retreated northward with regularly-spaced halts. Deglaciation by northward retreat of still-flowing ice is indicated in the Vermont Valley north of Bennington.

During the halt of the Vermont Valley lobe near Hale Mountain, a lake with the suggested name "Glacial Lake Shaftsbury" was formed with its water plane at about 900 feet. The dam for this lake was near Hoosic Falls, New York, and its outlet was around the south side of Potter Hill in New York.

Two sections on the east border of the Wilmington Quadrangle reveal two compact, sandy lodgement tills separated by five to fifteen feet of lacustrine sand. The lower till in both sections has a northwest fabric with a strong northerly component, and the upper has a strong fabric with distinct maxima at N30°W and N40°W. These are the only sections found in southern Vermont that indicate a possible record of multiple glaciation.

GEOCHEMISTRY OF A MEROMICTIC LAKE

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ABSTRACT

Numerous workers over a period of years have investigated the hydrology, geochemistry, biology, thermal structure and geologic history of Green and Round Lakes near Fayetteville, New York. Despite these investigations, a number of basic questions concerning these two mesomictic lakes remain unresolved.

A brief summary of data on thermal structure, biological observations and ideas advanced for the origin of these lakes is presented. The chemical and hydrologic balances is discussed in relation to our knowledge of chemical parameters.

(cont.)

Geochemistry of a Meromictic Lake (cont.)

Green Lake contains two well-defined water masses separated by a sharp gradient in salintiy. The deep mass is characterized by reducing conditions through which fall calcium carbonate precipitated in the surface mass and organic matter formed in the surface water. The sediments are characterized by alternating light and dark layers forming at the rate of about 0.1 mm/year. Dissolved total CO_2, PCO_2, C^{14}, and Sr^{90} were measured at various depths to determine the time constants of circulation and residence. The surface water has a mean residence time of about 2.5 years, and the deep water about 8 years. The increased total CO_2 and presence of H_2S in the deep mass are probably related to the action of sulfate-reducing bacteria located near the boundary layer between the water masses.

Major uncertainties include the amount and chemical character of ground water flowing into the deep water mass.

STRUCTURE OF THE NORTHERN HALF OF THE ROSSIE COMPLEX NORTHWEST ADIRONDACKS, NEW YORK

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ABSTRACT

The Rossie Complex is located in the Adirondack Lowlands at the intersection of the Hammond, Pope Mills, Natural Dam and Muskellunge Lake 7 1/2-minute quadrangles. Geologically the complex is bounded on the north by the Hyde School phacolith and on the south by the Payne Lake phacolith.

The stratigraphy of the northern part of the complex consists of nineteen concordant and three discordant units which have been folded into a series of broad open folds. The amplitudes of these folds increase from 2000 feet to about 4500 feet in a westerly direction. On the other hand, the wavelengths of the folds decrease from about 7000 feet to 3500 feet in the same direction. π - diagrams compiled for individual folds show a recurring pattern of double maxima representing the poles to planes of foliation of each limb of the fold. Separation of the individual folds into domains of different rock types suggests that the double maxima are a function of ductility differences between stratigraphic units of the folds. Great circles defined by the π - diagrams of the two rock-type domains are not well-developed but do suggest that the beta axes of the two domains are crossed. Double maxima would be developed in π - diagrams for domains of a fold which have different radii of curvature; however, in this case the great circles of the π -diagram would define the same beta axis. It is also thought that the double maxima developed by the poles to the planes of foliation might be a function of axial plane folding or refolding.

A fault with 3500 feet of right-lateral map separation is proposed for the western margin of the complex. Although there appears to be no direct evidence of faulting such as brecciation and/or mylonitization, there is ample indirect evidence of faulting:

(1) Disharmonic relationships of the fold which is inconsistent with the style of folding in the remainder of the complex;

(2) Fracture pattern developed in the nose of a tightly folded synform;

(3) Local steepening and re-orientation of the beta axis of the nose of the synform from S 2° W, 49° to S 12° W, 68°;

(4) Truncation of the splay in a gneiss unit by metagabbro, marble and pyritic gneiss units.

MINERAL — WATER EQUILIBRIUM, GREAT LAKES: ALUMINOSILICATES

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ABSTRACT

Sediments and interstitial water, cored from the Great Lakes, are analyzed mineralogically and chemically. Aluminosilicate - solution data are treated within thermodynamic equilibrium models.

Sediments from a granite basin lake (Onaping), and from the metasediment-situated North Channel (Lake Huron), provide "primary" source mineral types, i.e., feldspars, micas, and chlorite; sediments from limestone and shale terrane (Manitoulin Is., Lakes Erie and Ontario) are derived from "secondary", carbonate-clay mineral, sources.

The following observations are made:

(1) "Chlorite" and sodium feldspar are greatly undersaturated everywhere.

(2) Quartz is oversaturated in all interstitial waters.

(3) Amorphous silica - solution equilibrium fixes upper limits for dissolved silica concentration.

(4) Kaolinite is stable everywhere.

(5) Sodium montmorillonite - kaolinite equilibrium is approached closely in metasediment-derived systems. Calcium montmorillonite - kaolinite equilibrium is most closely achieved in granite and limestone sediments.

(6) Muscovite is generally unstable with respect to kaolinite. However, muscovite - kaolinite equilibrium apparently limits K^+/H^+ ratios to an upper value of ca. 10^4.

(7) Potassium feldspar - kaolinite equilibrium is very sensitive in a "push-pull" manner in the more "upstream" granite, metasediment, and limestone sediments (Lake Huron and northward).

(8) X-ray and optical studies confirm the presence of the minerals discussed.

(9) Aluminosilicate - solution equilibrium is prevalent in Great Lakes sediments. By virtue of this, the lake sediment - water systems control many aspects of their major ion chemistry.