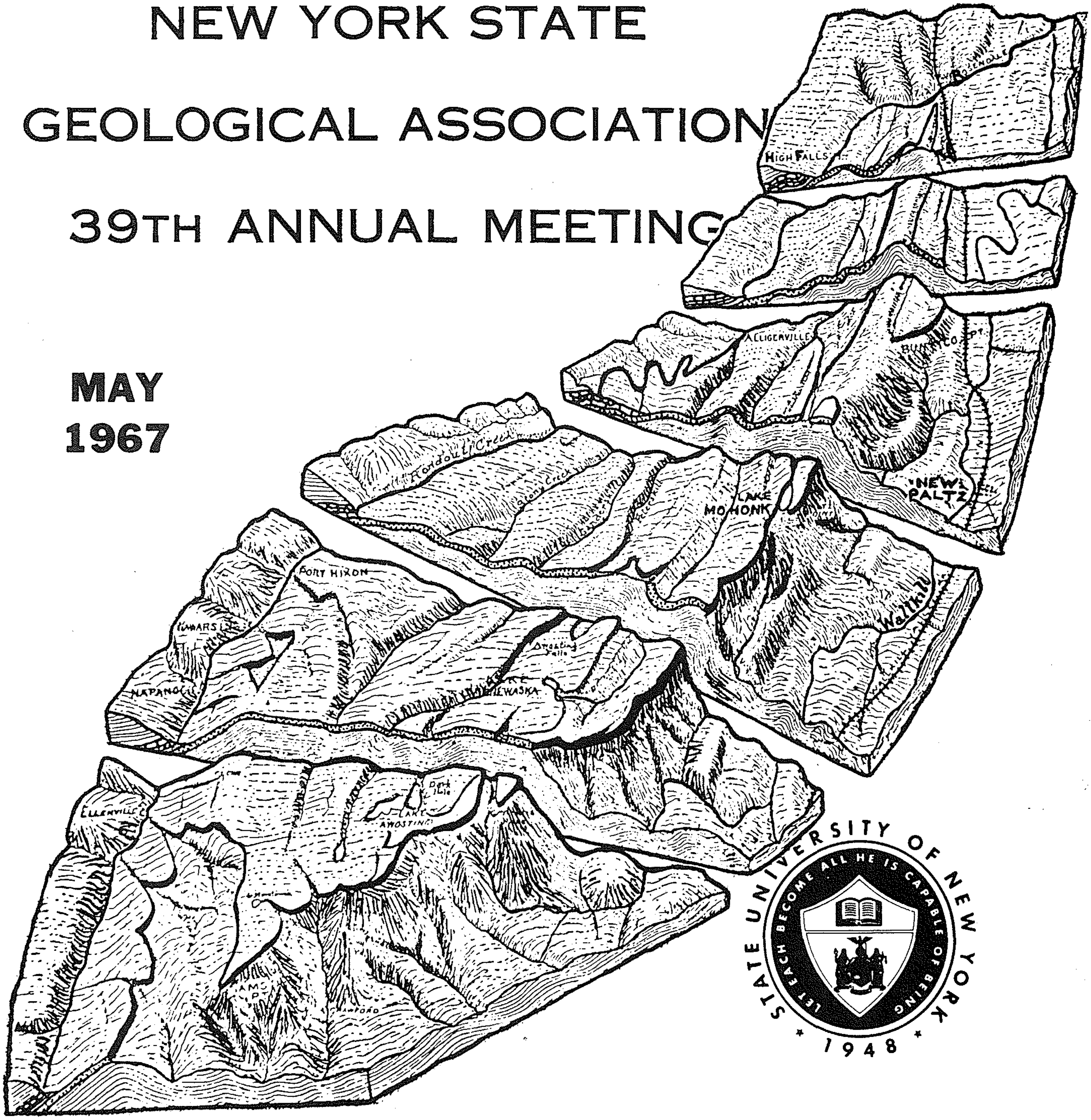
GUIDE BOOK

NEW YORK STATE

GEOLOGICAL ASSOCIATION

39TH ANNUAL MEETING

MAY
1967



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.

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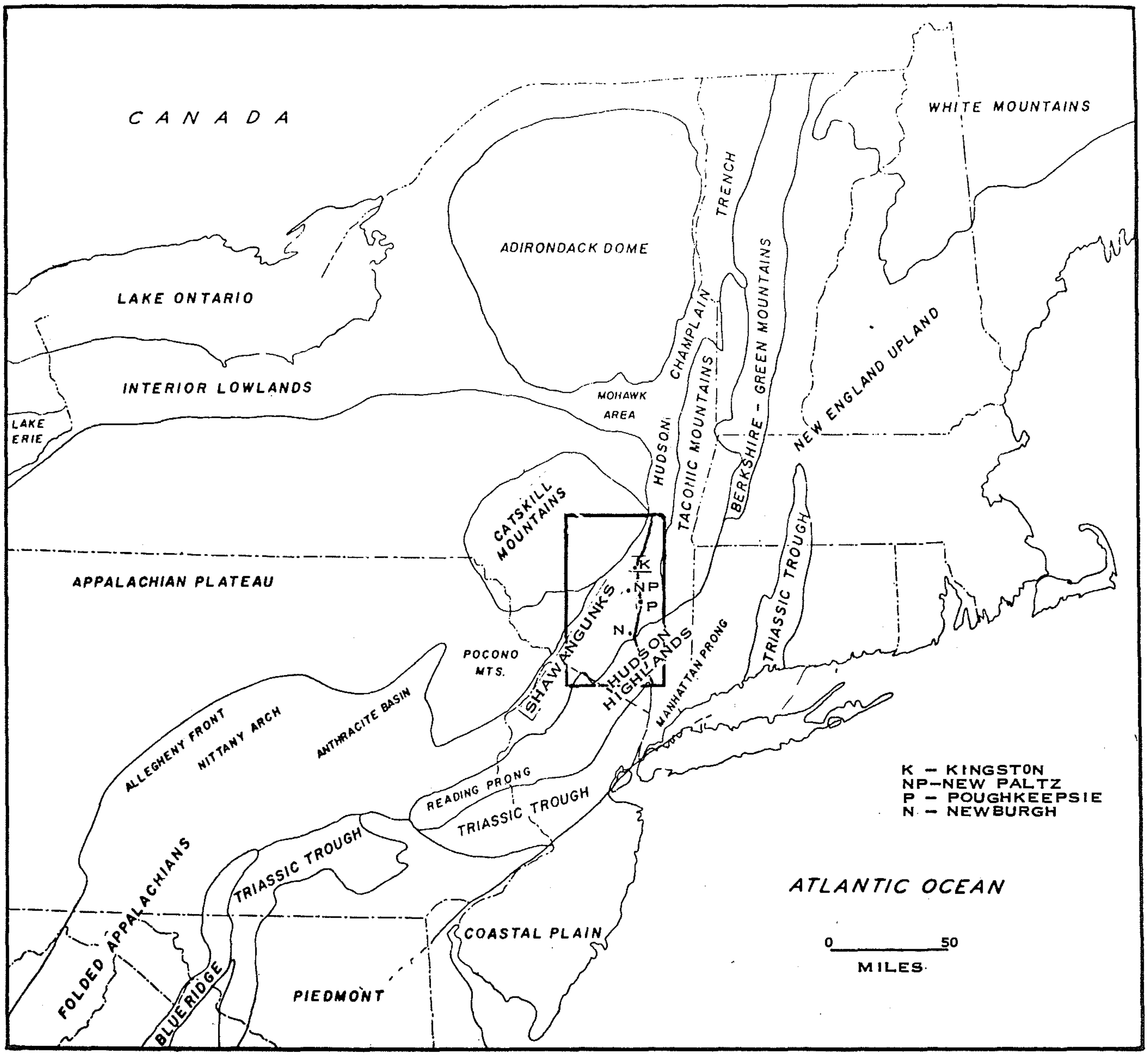


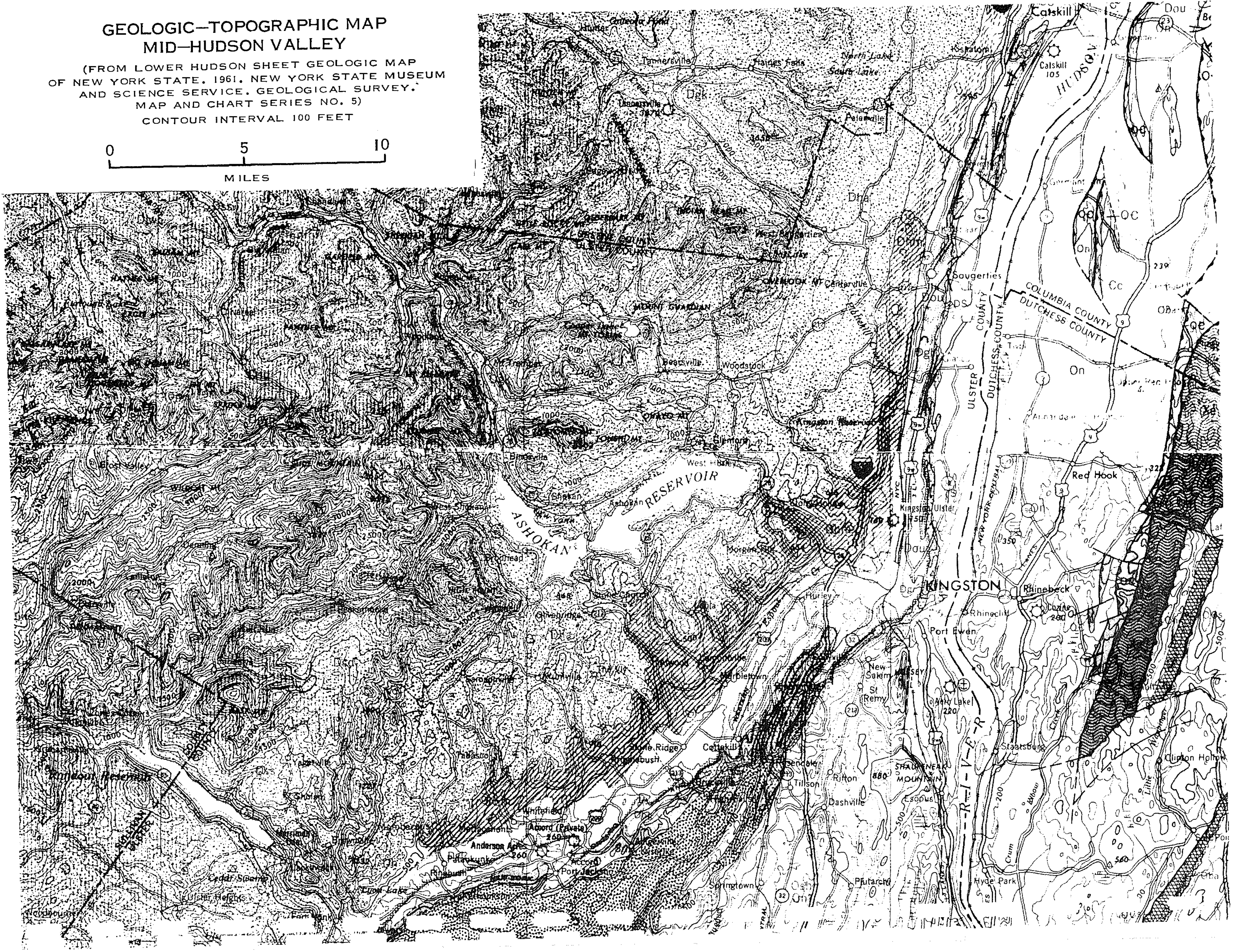
REGIONAL SETTING OF GEOLOGIC MAP

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)

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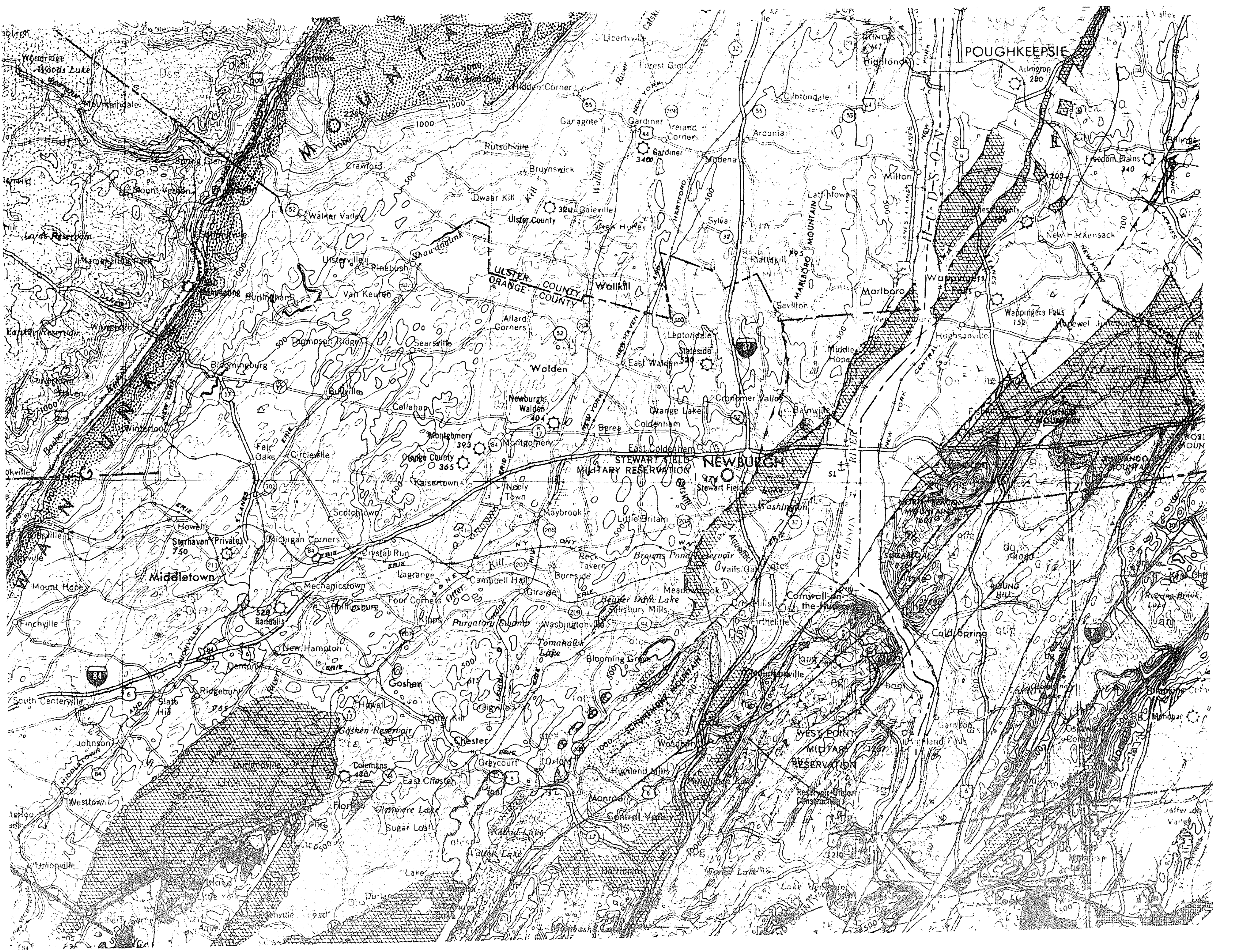

POUGHKEEPSIE
NEWBURGH
Middletown
Walden
Goshen
Chester
Wallkill
Marlboro
Milton
Highland
Clintondale
Ardonia
Modena
Gardiner
Ireland Corners
Ganagote
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Bruynswick
Crawford
Walker Valley
Ulsterville
Pinebush
Van Keuren
ULSTER COUNTY
ORANGE COUNTY
Allard Corners
Searsville
Thompson Ridge
Bloomingburg
Bullville
Cellahan
Montgomery
Kaisertown
Scotchtown
Circleville
Fair Oaks
Winterton
Howells
Michigan Corners
Crystal Run
Mechanicstown
Randalls
New Hampton
Denton
Ridgebury
Slate Hill
South Centerville
Westtown
Johnson
Finchville
Mount Hope
Leptondale
Stateside
East Walden
Berea
Coldenham
Orange Lake
Cronomer Valley
East Coldenham
STEWART FIELD
MILITARY RESERVATION
Stewart Field
Neely Town
Maybrook
Little Britain
Rock Tavern
Burnside
Campbell Hall
Lagrange
Four Corners
Phillipsburg
Kipps
Purgatory Swamp
Washingtonville
Salisbury Mills
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Craigville
Otter Kill
Goshen Reservoir
Howell
Greycourt
Oxford
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East Chester
Florida
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Ulster County
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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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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.

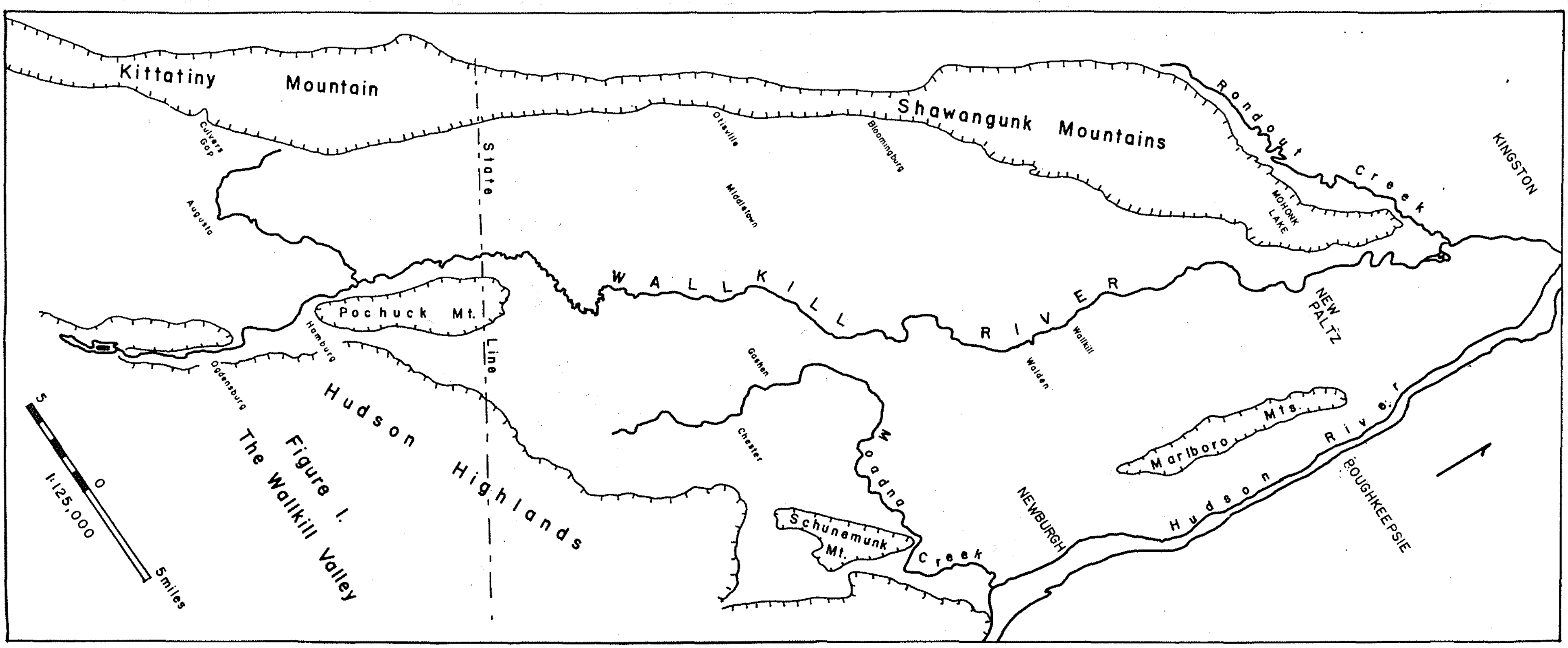


Figure I.
The Wallkill Valley

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.

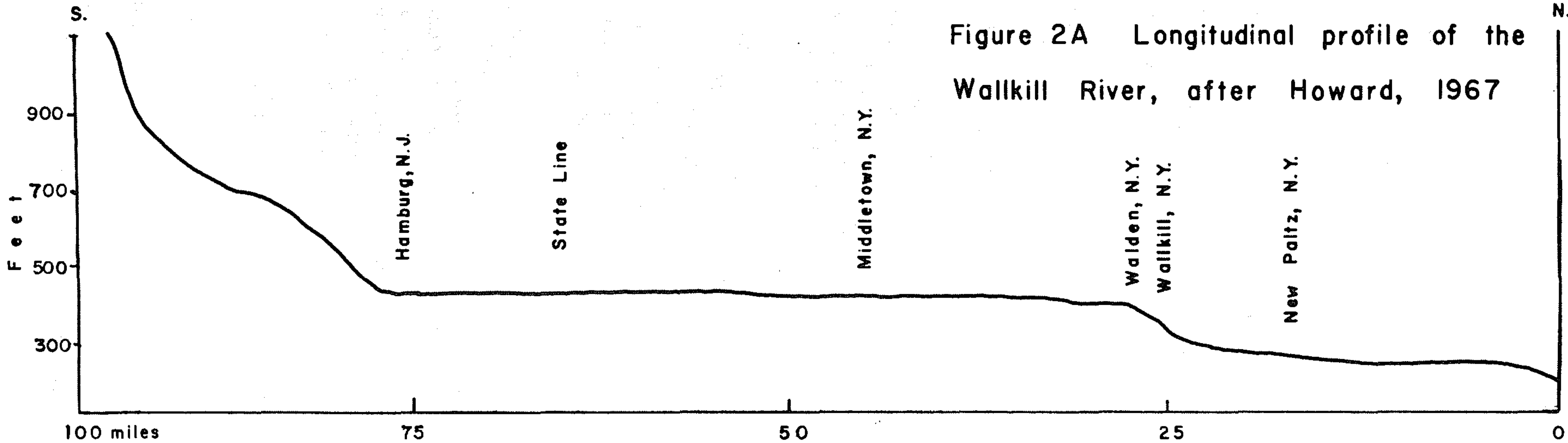


Figure 2A Longitudinal profile of the Wallkill River, after Howard, 1967

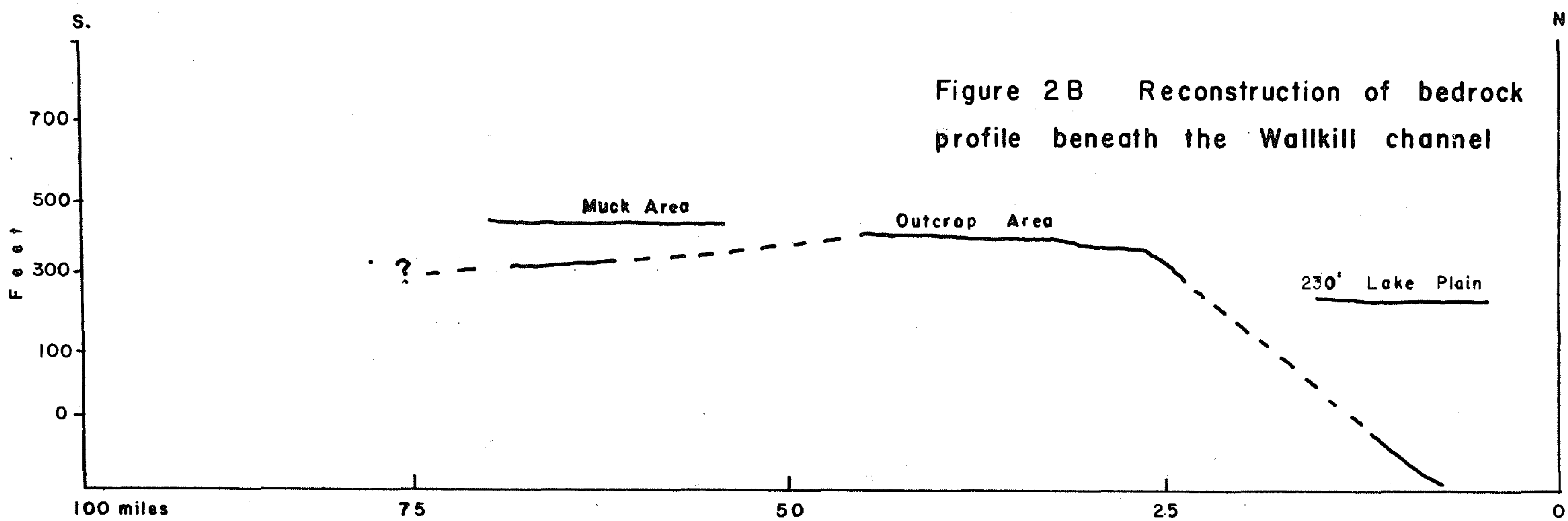


Figure 2B Reconstruction of bedrock profile beneath the Wallkill channel

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

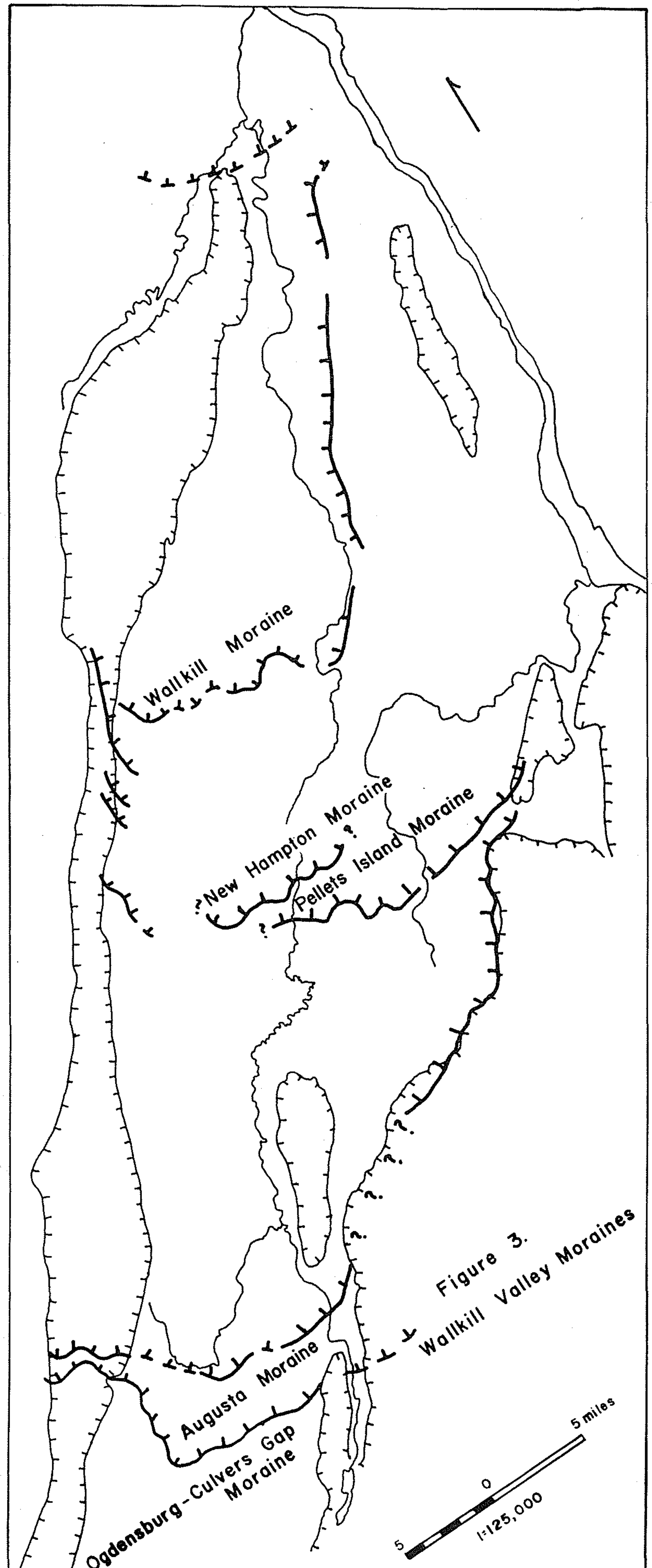
A third moraine is evident as a massive ridge of till and stratified drift athwart the Wallkill Valley two miles south of Goshen. This moraine is here named the Pellets Island Moraine for an exposure in the Orange County Sand and Gravel Co. pit (Stop A-3) at Pellets Island. The Pellets Island Moraine 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


Wallkill Moraine
New Hampton Moraine
Pellets Island Moraine
Augusta Moraine
Ogdensburg-Culvers Gap Moraine
Figure 3.
Wallkill Valley Moraines
5 miles
5
0
1:125,000

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.