STRATIGRAPHY OF THE NORTHEASTERN MANHATTAN PRONG, PEACH LAKE QUADRANGLE, NEW YORK - CONNECTICUT

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INTRODUCTION

The purpose of this trip is to consider the stratigraphy of the Manhattan Prong along the New York-Connecticut border, in the Peach Lake quadrangle (Fig. 1). Recent mapping in this area has suggested that a major stratigraphic revision is necessary. Overlying the Grenvillian rocks of the Fordham Gneiss and below the magnesian marbles of the Cambro-Ordovician Inwood Marble, a traceable suite of metasedimentary and metavolcanic rocks appears to exist. This suite, here informally named the "Ned Mountain Formation", includes the K-feldspar rich quartzites typical of the "Lowerre Quartzite"; but it also contains a variety of other lithologies, all of which have previously been assigned to either the Fordham Gneiss or to post-Lowerre Paleozoic units. Ways in which rocks of the "Ned Mountain Formation" can be distinguished from other units will be pointed out on the trip and in the text.

Recognition of this new, expanded, Late Precambrian to Early Cambrian unit will have important implications both for the rift-to-drift stage of geological history and (by its map scale distribution) for Paleozoic structures in the Manhattan Prong.

GEOLOGICAL SETTING

Rocks of the Manhattan Prong consist of Grenville basement gneisses and overlying Cambro-Ordovician strata. In the Croton Fall-Peach Lake area of New York, the Prong was multiply deformed and metamorphosed at K-feldspar-sillimanite grade during the Taconian orogeny. Later, probably during the Carboniferous, it was cut by shear zones and its K-feldspar-sillimanite assemblages locally retrograded (Brock and others, 1985; Brock & Brock, 1985a & b).

The generally accepted interpretation of the Prong's stratigraphy, familiar from the works of Hall (1968, 1979), Ratcliffe and Knowles (1969), and many others, consists of four major units (Table 1). The structurally lowest unit, Fordham Gneiss, is generally interpreted as a Grenvillian basement complex. Overlying it, the Cambrian Lowerre Quartzite, Cambro-Ordovician Inwood Marble, lower Middle Ordovician Walloomsac Schist (Manhattan A of Hall), and allochthonous Cambrian Manhattan Schist (Hall, 1968, 1979) comprise the accepted post-Grenville succession of the Manhattan Prong. Cameron's Line, which marks the boundary between the Manhattan Prong and overthrust Hartland terrane, nicks the northeastern border of the Peach Lake quadrangle (Fig. 2; Table 1).

The most compelling lines of evidence for the existence of the expanded Late Precambrian-Cambrian sequence of the "Ned Mountain Formation" come from a) the persistence of distinct lithologies in between the granulites of the Fordham Gneiss and the magnesian marbles of the Inwood (Fig. 2); b) traceability of rock units within this intervening sequence (Fig. 4); and c) truncation of units of the Fordham Gneiss against the base of this sequence (Fig. 2).

DESCRIPTION OF ESTABLISHED UNITS: FORDHAM GNEISS, INWOOD MARBLE, WALLOOMSAC SCHIST, MANHATTAN SCHIST, AND HARTLAND FORMATION

Fordham Gneiss. Each of the six units recognized in the Fordham Gneiss of the Peach Lake quadrangle is at least locally in contact with the "Ned Mountain Formation". Mineralogies of these units reflect their history of Grenvillian granulite-facies metamorphism, variably recrystallized at somewhat lower grade during the Taconian orogeny. These six units are:

Yf_I. Leuco- to mesocratic, medium-grained gneiss, with 3 mm- to 8 mm-

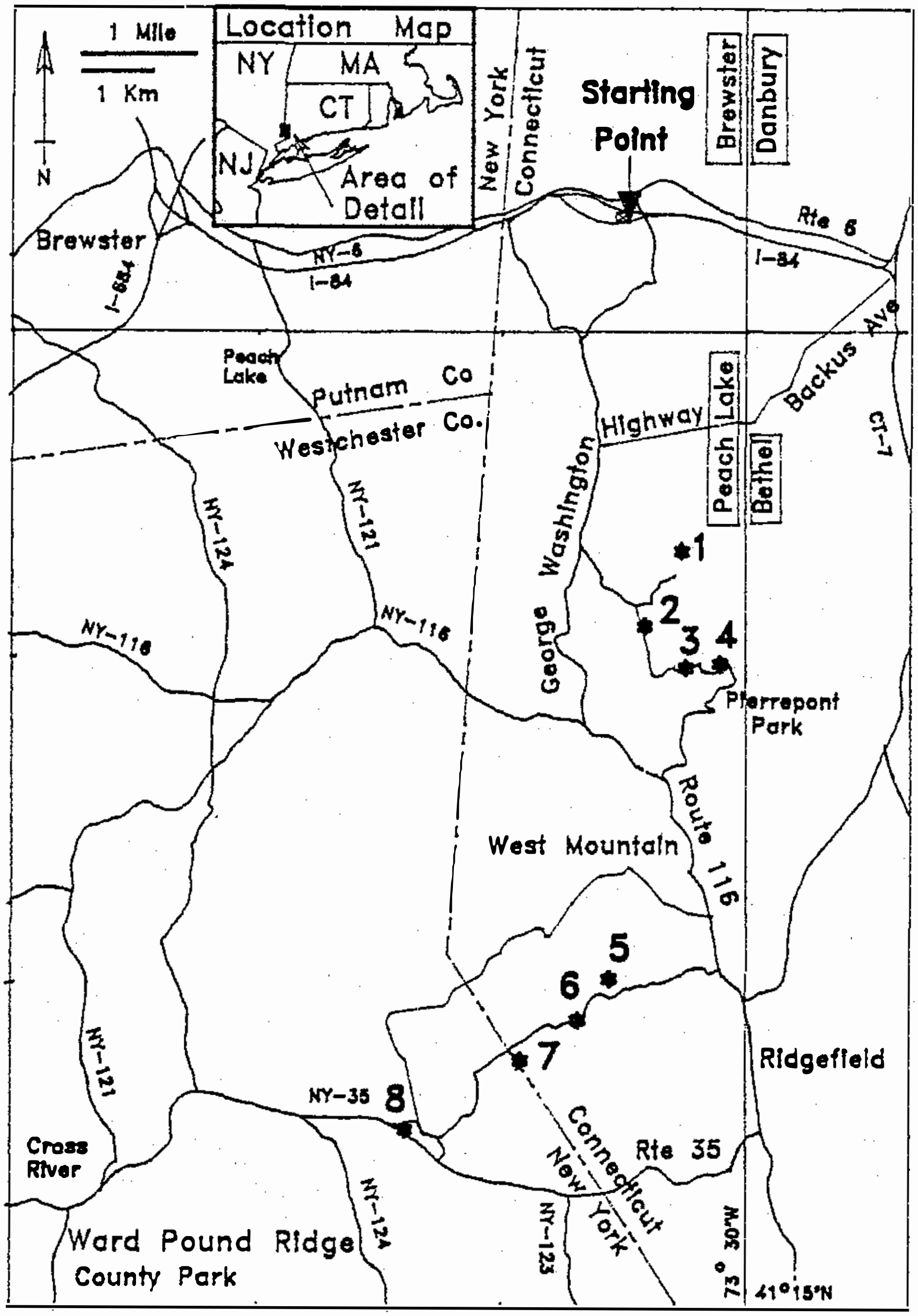
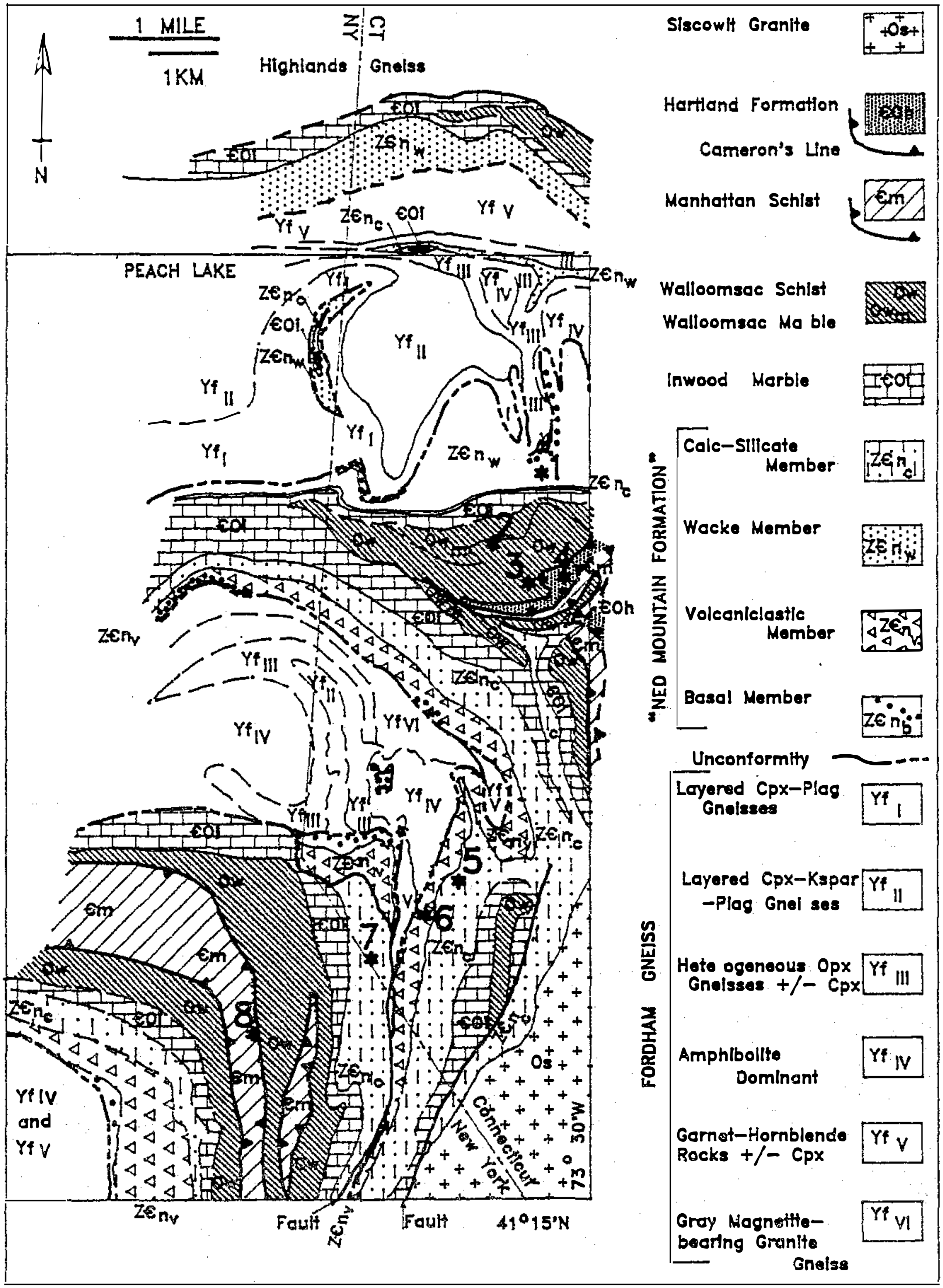


Figure 1. Location map showing field trip stops. Peach Lake & surrounding quadrangles are labeled.

Figure 2. (opposite) Geologic map of parts of the Peach Lake and Brewster quadrangles.


1 MILE
1KM
N
NY
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Highlands Gneiss
PEACH LAKE
€Ol
ZЄn_w
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Yf V
ZЄn_c
Yf III
Yf IV
Yf II
Yf I
ZЄn_b
1
3
€Oh
€m
ZЄn_v
Yf VI
5
6
7
8
Os
Yf IV and Yf V
Connecticut
New York
73° 30'W
Fault
41°15'N
Siscowit Granite
Hartland Formation
Cameron's Line
Manhattan Schist
Walloomsac Schist
Walloomsac Marble
Owm
Inwood Marble
"NED MOUNTAIN FORMATION"
Calc-Silicate Member
Wacke Member
Volcaniclastic Member
Basal Member
Unconformity
FORDHAM GNEISS
Layered Cpx-Plag Gneisses
Layered Cpx-Kspar-Plag Gneisses
Heterogeneous Opx Gneisses +/- Cpx
Amphibolite Dominant
Garnet-Hornblende Rocks +/- Cpx
Gray Magnetite-bearing Granite Gneiss

thick discontinuous streaks and broader spaced (0.5-2.0 m) compositional layering. Mesocratic to leucocratic layers are plagioclase-quartz-hornblende-biotite±clinopyroxene; the amphibolites are hornblende-rich. Minerals show little planar parallelism.

Yf_{II}. Leuco- to mesocratic quartz-2-feldspar-hornblende-biotite±clinopyroxene streaky gneiss, again with amphibolitic interlayers. This unit strongly resembles Yf_{I} and is distinguished mainly by its K-feldspar content.

Yf_{III}. Interlayered coarse-grained, orthopyroxene-bearing gneisses (Stop 1A), consisting of a) light-colored quartz-plagioclase-orthopyroxene-hornblende-biotite±K-feldspar±garnet gneiss, with dark orthopyroxene-hornblende-plagioclase layers; b) mesocratic quartz-plagioclase-orthopyroxene-clinopyroxene-hornblende±biotite gneiss; and amphibolite-facies equivalents, remetamorphosed during the Taconian orogeny. Relicts of orthopyroxene embayed by cummingtonite are often found in these rocks. The unit is recognized at amphibolite facies in part by its characteristic compositional layering, with layers 1 to 5 cm thick. At amphibolite facies, these layers consist of a) quartz-plagioclase-hornblende-biotite-garnet±relict orthopyroxene, with amphibolite and biotite-rich interlayers, and b) quartz-plagioclase-hornblende-biotite±clinopyroxene layers. The amphibolite-facies gneisses are much better foliated than the granulite-facies rocks, due to the increase in biotite and decrease in pyroxene content.

Yf_{IV}. Amphibolite and amphibole-plagioclase-quartz-biotite gneisses, with minor pyroxene. This unit is well-layered but appears to be much more uniform and melanocratic than Yf_{III}. These rocks are medium-grained and equigranular.

Yf_{V}. Melanocratic to leucocratic, coarse-grained hornblende-garnet-plagioclase-clinopyroxene±orthopyroxene and quartz-plagioclase-hornblende-biotite gneisses (Stop 1B). At peak metamorphic grade, these rocks often have a red-and-green appearance due to intergrowth of garnet and clinopyroxene. Hornblende appears to be (at least in part) the product of Taconian metamorphism. Associated with the garnet-clinopyroxene gneiss in this unit is a rusty-staining, medium-grained, quartz-plagioclase-biotite-garnet-graphite granofels. Amphibolites are also common and the unit may in fact grade into Yf_{IV}. Some coarse-textured hornblende-clinopyroxene-biotite-plagioclase-quartz gneisses are interpreted as amphibolite-facies equivalents.

Granites of probable Grenville and Taconian ages are found with all the above units. Some of the Grenvillian granites are hornblende-bearing. One granite is large enough to be considered as a separate unit:

Yf_{VI}. Quartz-plagioclase-K-feldspar-biotite-magnetite±hornblende granitic gneiss. The gneiss contains amphibolitic layers. This grey granitic gneiss is remarkable for its modal abundance (up to 5%) of 1 to 3 mm clots of magnetite.

Many of the Fordham units share certain features that help distinguish them from post-Grenvillian rocks; this is especially true where effects of Taconian deformation and metamorphism are minimal. In such areas, Fordham rocks are typically medium- to coarse-grained (most grains 2 mm to 15 mm in diameter) and well-layered. They occasionally have a well-developed linear fabric, but are poorly foliated. They have relatively little biotite and proportionally large amounts of pyroxene. Feldspars often appear waxy and somewhat greenish. Equant and tabular grain shapes predominate, suggesting extensive grain growth after Grenvillian deformation. Post-Grenvillian rocks of similar compositions, in contrast, are finer-grained, better-foliated, contain more biotite, and have white, grey, or pink feldspar. A tendency towards mineral segregation and a high incidence of ribbon quartz (as well as of flattened grains of minerals like garnet) contributes to the pronounced fabric characteristic of post-Grenvillian rocks in the area.

Metamorphic grade, as reflected by mineralogy, can help distinguish Fordham and younger rocks. Grenvillian metamorphism attained higher grade than any known in the Paleozoic rocks of the area: coexistence of hypersthene and K-feldspar has been documented in the Fordham (Brock and Brock, 1983), and the garnet-clinopyroxene-plagioclase assemblages of Yf_V are distinctive. For many bulk compositions, however, mineralogies of the Fordham and younger rocks can be similar.

Taconian metamorphism was at least K-feldspar-sillimanite grade throughout the Peach Lake quadrangle. But within the Peach Lake quadrangle, an early Taconian metamorphic gradient has recently become evident. Peak assemblages generally increase in grade towards the northeast; the highest grade was reached in the vicinity of Pierrepont Park, Connecticut (Fig. 1). For example, many mafic units of Paleozoic age contain cummingtonite-hornblende-garnet-biotite (orthopyroxene-absent) assemblages in the southern Peach Lake quadrangle. Hypersthene-hornblende-biotite is common in Paleozoic rocks in the northern area, where peak Taconian assemblages do not appear to contain cummingtonite. Hartland and Walloomsac lithologies include two-pyroxene-bearing amphibolites in the northeastern Peach Lake quadrangle (Stop 4). This distribution of mineral assemblages is consistent with a transition from barely K-feldspar-sillimanite grade upwards into granulite facies (Hollocher, 1985). In the peak metamorphic zone, late Taconian K-feldspar-sillimanite assemblages overprint cordierite-garnet-sillimanite grade rocks (Stop 3), and sparse periclase has been found in magnesian marbles (Stop 1E). Assemblages in marbles, pelites and mafic rocks all apparently reflect the early Taconian regional gradient.

But even in the zone of Taconian metamorphism, Fordham and younger rocks remain texturally distinct. The orthopyroxene-bearing amphibolites of Paleozoic age are fine-grained, well-foliated, and in hand specimen resemble their cummingtonite-bearing counterparts much more than the orthopyroxene gneisses of the Fordham (Yf_{III}). Petrographic characteristics, combined with stratigraphic relationships, permit Grenvillian and younger rocks (including the "Ned Mountain Formation") to be confidently distinguished in most cases.

Paleozoic Strata: Inwood, Walloomsac, Manhattan, and Hartland. The distinctive magnesian lithologies of the Cambro-Ordovician Inwood Marble (Stop 1E) form an invaluable stratigraphic marker (Fig. 4 & Table 1). This unit is correlated with dolomites of the Wappinger Group and is inferred to have been deposited in a stable shelf environment. The marble of the Inwood is often calcitic in the Peach Lake quadrangle; forsterite+calcite coexist, and only low-silica Inwood retains dolomite (Fig. 3). The marbles are white-weathering where calc-silicate minerals are minor; calcite-clinopyroxene-forsterite-phlogopite marbles appear greenish and calcite-dolomite-forsterite-phlogopite marble weathers buff. Opaque minerals are generally very minor (well under 1%), but, rarely, graphite is abundant. Phlogopite-rich and quartzite interlayers occur. The Inwood has not been subdivided here, because a relative scarcity of outcrop makes it difficult to determine its internal stratigraphy.

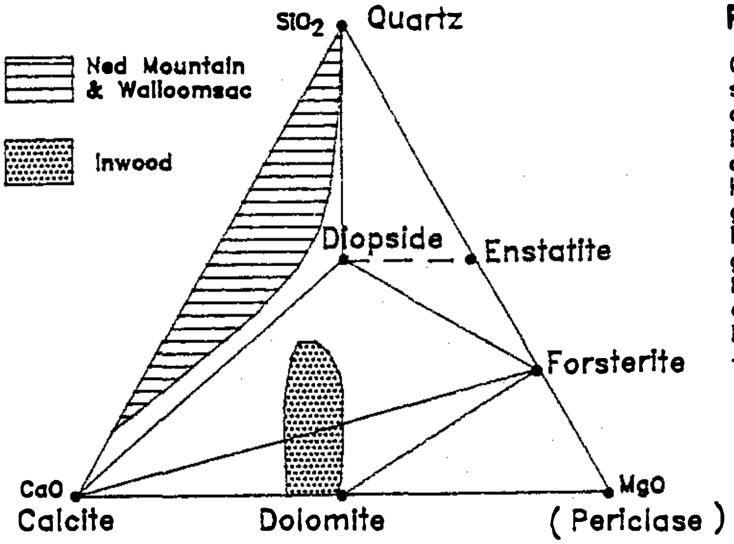


Figure 3.

$CaO-MgO-SiO_2$ plot showing compositional differences within the Paleozoic marbles and calcsilicates. K-feldspar-sillimanite grade assemblages are illustrated; at higher grade in the northern Peach Lake quad, dolomite begins to break down to calcite + periclase

In the area of peak Taconian metamorphism, Mg-Al spinel partly replaced by phlogopite is sometimes found; and dolomite has begun to dissociate according to the reaction

$$CaMg(CO_3)_2 = MgO + CaCO_3 + CO_2$$

dolomite = periclase + calcite + carbon dioxide

Decomposition of dolomite requires extremely high temperatures and is inhibited by high partial pressures of CO_2. The presence of periclase and spinel in the Inwood suggest Taconian peak temperatures >800°C and relatively low pressures (Winkler, 1974).

Unconformably overlying the Inwood, the lower Middle Ordovician Walloomsac Schist (Table 1) contains a basal marble and calc-silicate unit (Ow_m). Ow_m can be distinguished from Inwood in a number of ways. Graphite is common and the unit is sulfidic and rusty-weathering. Walloomsac marbles are much less magnesian than the Inwood (Fig. 3); typical mineral assemblages include calcite-clinopyroxene-quartz-plagioclase-K-feldspar. In Ow_m, carbonate is less abundant and silicates generally more abundant than in the Inwood Marble. The rocks often have a green-and-white speckled appearance due to the abundant green clinopyroxene grains.

Walloomsac marble (Stop 2) is associated with Walloomsac granofelses and schists (O_w). Walloomsac granofelses are fine-grained rocks containing quartz-plagioclase-biotite-garnet±graphite, and little (1-2%) or no K-feldspar (Stop 2). The granofelses tend to break in a slabby fashion. Walloomsac schists usually contain quartz-plagioclase-K-feldspar-garnet-sillimanite-biotite±graphite, though cordierite is present at peak metamorphic grade (Stop 3). Minor cummingtonite-bearing amphibolites also occur in the formation. Bedding is well-defined in the calcareous and sandy parts of the Walloomsac, and poorly defined in the thicker-bedded schists. The schists and granofelses, like the calc-silicates, are usually sulfidic (containing pyrrhotite and pyrite) and rusty-weathering.

Manhattan Schist (Stop 8) is dominantly quartz-plagioclase-K-feldspar-biotite-sillimanite-garnet schist. In contrast with the more sulfidic Walloomsac, ilmenite and magnetite are the major opaque Fe minerals. Hornblende

TABLE I. Stratigraphic Correlation between Peach Lake and Surrounding Areas

	Drake (1969, 1984) Delaware Valley N.J.-PA.	Prucha et al. (1968) Northeastern Manhattan Prong	This Report Northeastern Manhattan Prong	Hall (1968, 1979) Southeastern Manhattan Prong	Fisher (1977) Knopf (1962) Dutchess County, N.Y.
Structural Position of Overthrust Units			Hartland Formation Manhattan Schist	Manhattan Schist, Members B & C	
Middle Ordovician	Martinsburg Formation Jacksonburg Limestone	Manhattan Schist	Walloomsac Schist Marble	Manhattan Schist, Member A Marble	Walloomsac Formation Balmville Limestone
Early Ordovician	Beekmantown Group	Inwood Marble	Inwood Marble	Inwood Marble E D	Stockbridge Group: Copake Limestone Rochdale Limestone Halcyon Lake
Cambrian	Allentown Dolomite Leithsville Formation			C B A	Wappinger Group: Briarcliff Dolomite Pine Plains Formation Stissing Dolomite
	Hardyston Quartzite		"Ned Mountain Formation": Calc-silicate Member Volcaniclastic Member Wacke Member Basal Member	Lowerre Quartzite	Poughquag Quartzite
Proterozoic Z	Chestnut Hill Formation			? Yonkers Gneiss ?	
Proterozoic Y	Gneisses of the Reading Prong	Fordham Gneiss	Fordham Gneiss	Fordham Gneiss	Gneiss

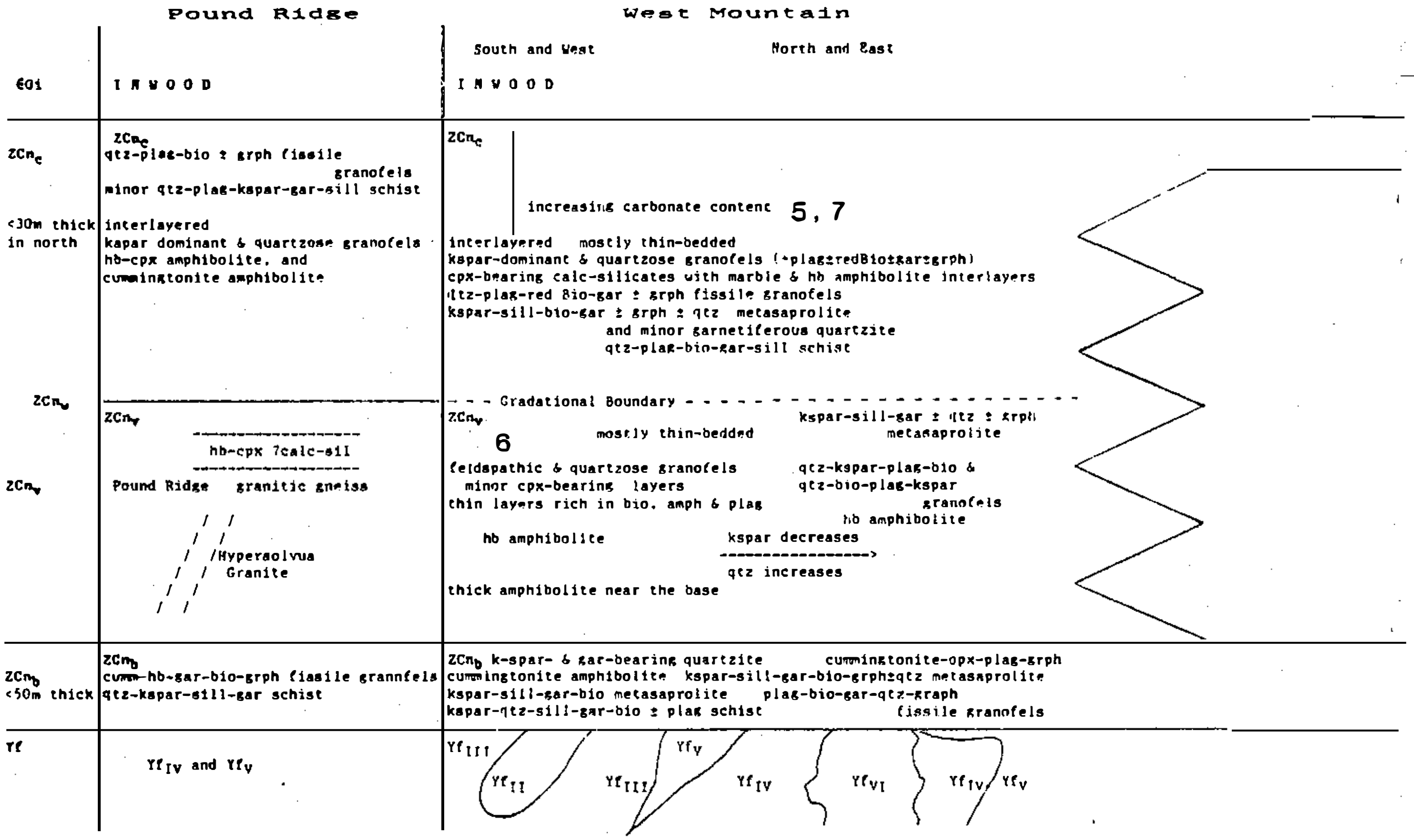
amphibolite is commonly interlayered with the pelites; garnet-rich granofelsic layers up to 60 cm thick are scattered throughout. This unit is thought to be of Cambrian age, a correlative of the Hoosac Formation (Rodgers, 1985) allochthonously emplaced over the Middle Ordovician Walloomsac (Table 1) (Hall, 1968).

Hartland Formation (Stop 4), undivided here, consists of hornblende-orthopyroxene-plagioclase amphibolites, thick-bedded quartz-plagioclase-biotite granofelses, and rhythmically bedded schist-and-quartz-feldspar granofels. Cameron's Line marks the early (D_1) Taconian thrust along which the Cambro-Ordovician Hartland Formation was emplaced against the rocks of the Manhattan Prong (Fig. 2 & Table 1).

THE "NED MOUNTAIN FORMATION": LITHOLOGIES AND STRATIGRAPHY

The lower limit of the "Ned Mountain Formation" is defined by the post-Grenville unconformity along which the units of the Fordham Gneiss are truncated. The upper limit is set by the magnesian marbles of the Inwood, which are succeeded at structurally higher positions by Walloomsac, Manhattan, and Hartland lithologies. Between these two limits, a complex suite of rocks with its own distinctive stratigraphy can be traced (Figs. 2 & 4).

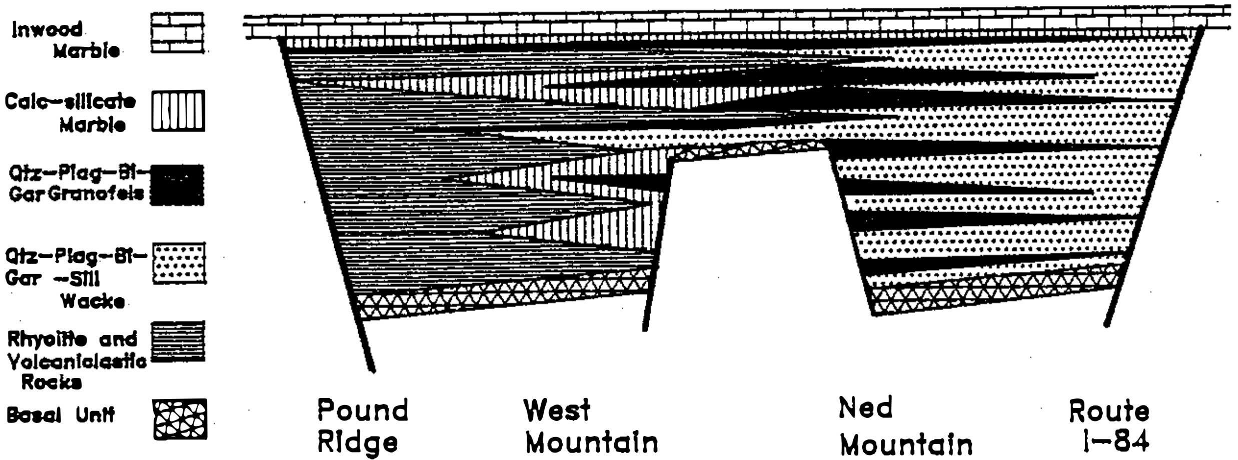
Figure 4. FACIES RELATIONSHIPS WITHIN THE "NED MOUNTAIN FORMATION"

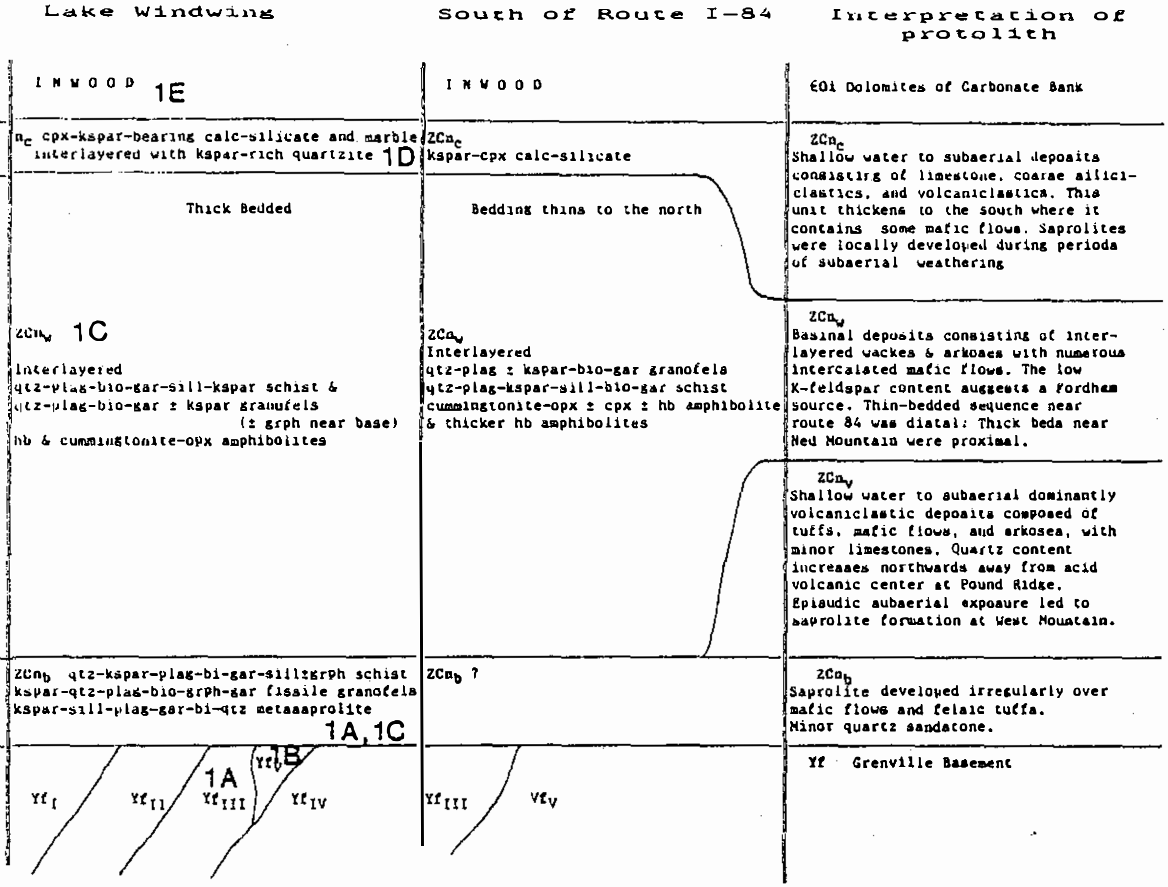


Abbreviations: bio = biotite; redBio = red biotite;
cpx = clinopyroxene; opx = orthopyroxene
gar = garnet; grph = graphite; hb = hornblende;
kspar = potash feldspar; opx = orthopyroxene; qtz = quartz;
plag = plagioclase; redBio = red biotite; sill = sillimanite

The large numbers indicate the stops at which the unit can be seen.

Figure 5. Interpretation of Facies Relationships within the "Ned Mountain Formation"





Lake Windwing	South of Route I-84	Interpretation of protolith
INWOOD	INWOOD	ЄOi Dolomites of Carbonate Bank
n_c cpx-kspar-bearing calc-silicate and marble interlayered with kspar-rich quartzite	$ZЄn_c$ kspar-cpx calc-silicate	$ZЄn_c$ Shallow water to subaerial deposits consisting of limestone, coarse silici-clastics, and volcaniclastics. This unit thickens to the south where it contains some mafic flows. Saprolites were locally developed during periods of subaerial weathering
Thick Bedded $ZЄn_w$ Interlayered qtz-plag-bio-gar-sill-kspar schist & qtz-plag-bio-gar ± kspar granofels (± grph near base) hb & cummingtonite-opx amphibolites	Bedding thins to the north $ZЄn_w$ Interlayered qtz-plag ± kspar-bio-gar granofels qtz-plag-kspar-sill-bio-gar schist cummingtonite-opx ± cpx ± hb amphibolite & thicker hb amphibolites	$ZЄn_w$ Basinal deposits consisting of interlayered wackes & arkoses with numerous intercalated mafic flows. The low K-feldspar content suggests a Fordham source. Thin-bedded sequence near route 84 was distal; Thick beds near Ned Mountain were proximal.
		$ZЄn_v$ Shallow water to subaerial dominantly volcaniclastic deposits composed of tuffs, mafic flows, and arkoses, with minor limestones. Quartz content increases northwards away from acid volcanic center at Pound Ridge. Episodic subaerial exposure led to saprolite formation at West Mountain.
$ZЄn_b$ qtz-kspar-plag-bi-gar-sill±grph schist kspar-qtz-plag-bio-grph-gar fissile granofels kspar-sill-plag-gar-bi-qtz metasaprolite	$ZЄn_b$?	$ZЄn_b$ Saprolite developed irregularly over mafic flows and felsic tuffs. Minor quartz sandstone.
		Yf Grenville Basement

This intervening unit, "Ned Mountain Formation", contains a wide variety of lithologies. It appears to be the product of a highly variable and rapidly evolving depositional environment. Significant facies changes exist within the Peach Lake area (see Figs. 4 & 5). The "Ned Mountain" has been provisionally subdivided into four members, each of which is lithically variable.

<u>"Ned Mountain Formation", Basal Member</u>. The basal unit ($ZЄn_b$) contains several rock types, some quartz-rich, others quartz-poor. One common lithology is a sulfidic, rusty-weathering, graphite-bearing, fissile, biotite-rich granofels (Stop 1A). Plagioclase is the dominant feldspar in this lithology, though K-feldspar is locally important. The biotite-rich granofelses sometimes contain minor cummingtonite (or orthopyroxene at higher grade). Graphite has been found with cummingtonite-garnet or orthopyroxene-garnet in several localities. Cummingtonite-bearing amphibolites are also found locally in the Basal Member of the "Ned Mountain Formation"; they contain 5%-10% quartz, in addition to plagioclase-hornblende-biotite-cummingtonite. The quartz content of cummingtonite-bearing granofelses is variable, generally ranging from 20% to 60%. The graphitic, cummingtonite-bearing granofelses are tentatively interpreted as organic-rich lacustrine sediments derived from weathered basalts.

The remaining lithologies of the Basal Member are K-feldspar-rich granofels, quartzite with minor garnet±K-feldspar±plagioclase, and distinctive, aluminous rocks low in quartz but rich in K-feldspar. The K-feldspar-rich granofelses contain quartz-K-feldspar-biotite-plagioclase. They are similar to the K-feldspar-rich rocks of the overlying Volcaniclastic Member of the "Ned Mountain Formation", and are interpreted as somewhat weathered, rhyolitic ash. The low-quartz rocks contain assemblages of K-feldspar-garnet-biotite-sillimanite±quartz±plagioclase. The low silica, high alumina, and high potash content of these rocks lead them to be interpreted as metasaprolites derived from and/or mixed with K-feldspar-rich volcaniclastic material. Some metasaprolites contain magnetite, suggesting deposition in a relatively oxidizing (subaerial?) environment; others, which contain graphite and iron sulfides, may consist of material washed into nearby, stagnant lakes.

To summarize, the Basal Member is interpreted as the product of variably weathered rhyolitic and basaltic rocks. Some units, particularly the amphibolites, may have undergone little alteration at the surface; others, like the quartz-rich cummingtonite-bearing lithologies and quartz-feldspar granofels, may have been arenaceous sediments derived from volcanic rocks. The sandy sediments may have been deposited in lakes, where they and saprolitic material washed in from adjacent highlands could mix with organic material. At one locality a thin-bedded quartzite (>80% quartz) contains thin laminae of biotite-garnet-cummingtonite and a thicker (>1.5 cm) quartz-free layer of K-feldspar-biotite-garnet-sillimanite-magnetite. An amphibolite adjacent to the quartzite may represent the source of the mafic volcanic debris. The rock records deposition of quartz-rich sands, saprolite, and mafic volcanic debris at close-spaced intervals.

The ZЄn_b member has been found overlying each of the Fordham lithologies recognized in the Peach Lake area (Figs. 2 & 4). Possible discontinuity of the unit can be explained by topographic relief on the post-Grenvillian erosional surface (Fig. 5). The ZЄn_b unit is generally reminiscent of the Chestnut Hill Formation of Drake (1984) in the Reading Prong of Pennsylvania. The Chestnut Hill Formation occupies the same stratigraphic position as the "Ned Mountain Formation" (Table 1): it overlies the Grenvillian basement, and underlies the Cambro-Ordovician dolomite sequence. It consists of arkose, ferruginous quartzite, metarhyolite, and metasaprolite (Drake, 1984). Drake (1969) identified the metasaprolite on the basis of its chemistry. Composed of only 42.7% SiO_2 and 0.16% CaO, in contrast to 20.2% Al_2O_3 and 7.9% K_2O, its composition is similar to that of saprolite derived from volcanic rocks of the Catoctin Formation in the Blue Ridge (Reed, 1955). The "low-quartz", K-feldspar-rich aluminous rocks of ZЄn_b probably have a similar origin.

Rocks immediately overlying the Basal Member of the "Ned Mountain Formation" are divided into two units: the Volcaniclastic Member (ZЄn_v) in the south, and Wacke Member (ZЄn_w) in the northern Peach Lake quadrangle. Lithologies in these two members seems to represent environments changing from subaerial volcaniclastic to a distal, basinal setting (Figs. 4 & 5).

"Ned Mountain Formation", Volcaniclastic Member (ZЄn_v). The Volcaniclastic Member is composed of K-feldspar-plagioclase-quartz-biotite granitic gneiss, feldspathic granofelses and hornblende±clinopyroxene amphibolites. The granitic gneiss is coarse- to fine-grained, highly feldspathic (K-feldspar+plagioclase ~70%), and very leucocratic; mafic minerals, principally biotite, are usually <5% of its modal composition. Rocks of this description are interpreted as metarhyolites. The granofelses are medium- to fine-grained, richer in quartz (ranging up to ~60%), and contain biotite-rich beds. Compositional layering, which ranges from a few mm to a couple of cm thick, is characteristic of the granofels. This layering is not compatible with a strictly igneous protolith. K-feldspar content of the granofels varies, often being ~55%. These rocks are thought to be volcaniclastic, with their relative quartz and biotite enrichment due to weathering of rhyolitic material or mixture with other sediments. The granofelses are hornblende±clinopyroxene bearing near the top of the $Z\mathcal{E}n_v$, and contain lenses and beds of calc-silicate (Stop 6). At West Mountain, the Volcaniclastic Member grades upwards into the clinopyroxene-bearing arkoses, marble, and biotite granofelses of the Calc-silicate Member.

Granitic gneiss is thickest at Ward Pound Ridge County Park (Figs. 1 & 4) in the southern Peach Lake quadrangle. This is the "Pound Ridge Granitic Gneiss" of Scotford (1956). In the southern West Mountain area, on the other hand, the Volcaniclastic Member is dominated by granofelses and amphibolite. On the north side of West Mountain, $Z\mathcal{E}n_v$ contains hornblende amphibolites, graphite-bearing metasaprolite (similar to that in $Z\mathcal{E}n_b$), and quartz-rich quartz-plagioclase-biotite-K-feldspar granofelses. Rhyolitic volcaniclastic material appears to be less abundant and/or more altered in this region. A dike of one-feldspar, mesoperthitic, hypersolvus granite that lies within the microcline-rich granitic gneiss of Pound Ridge is interpreted as a feeder to a volcanic vent. Pound Ridge is inferred to have been the regional center of rhyolitic volcanic activity. North of Pound Ridge, granofelses of the Volcaniclastic Member appear to reflect increasing degrees of weathering and transportation.

The Yonkers gneiss of southern Westchester County (Table 1) is lithically similar to the "Pound Ridge granitic gneiss" and occupies a similar stratigraphic position. Hall (1979) noted truncation of units of the Fordham under the Yonkers, and suggested that the Yonkers might represent felsic volcanics or arkoses lying over an unconformity. Geochronological studies on both granitic gneisses support their assignment to Late Precambrian-Early Cambrian time. The Pound Ridge has a Rb-Sr whole-rock age of 579±21 Ma (Mose and Hayes, 1975)[1]. Rb-Sr whole-rock studies on the Yonkers Granitic Gneiss have yielded ages of 563±30 Ma (Long, 1969) and 530±43 Ma (Mose, 1981). Zircon from the Yonkers gives a nearly concordant U-Pb age around 515 Ma (Grauert and Hall, 1974). Grauert and Hall (1974) found Middle Proterozoic inherited components in zircons from the Fordham, Manhattan, and Lowerre. Only zircons from the Yonkers were free of Grenvillian contamination. This indicates an igneous origin for the Yonkers Gneiss during Late Precambrian to Cambrian time.

"Ned Mountain Formation", Calc-silicate Member. The Volcaniclastic Member grades upwards into the Calc-silicate Member of the "Ned Mountain Formation" (Stops 5 & 7) ($Z\mathcal{E}n_c$, Fig. 4). This unit contains a mostly thin-bedded (0.5 to 10 cm) sequence of clinopyroxene-bearing granofelses and calc-silicates, calcareous marble, K-feldspar-rich granofels, quartz-plagioclase-biotite±K-feldspar±garnet±graphite granofelses, occasional hornblende and cummingtonite

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[1] All Rb-Sr ages have been recalculated using a decay constant of $1.42 \times 10^{-11}\ \mathrm{yr}^{-1}$.

amphibolites, a few saprolitic (low-quartz, K-feldspar-rich, sillimanite-bearing) layers, and minor quartz-plagioclase-biotite-garnet-sillimanite±K-feldspar metawackes. The K-feldspar-rich granofelses are indistinguishable from the granofelses of the underlying Volcaniclastic Member, and are thought to have a similar origin. Lithologies seem to grade continuously from rhyolitic towards calc-silicate (K-feldspar-rich, variable carbonate and clinopyroxene content), from rhyolite towards wacke (with increasing quartz and biotite, decreasing K-feldspar, ± graphite, garnet, and sillimanite) and from rhyolite towards saprolite. Thick calcite, low-Mg marbles (Fig. 4) lie near the top of this unit in the West Mountain area. Tourmaline is an occasional accessory in the granofelses, calc-silicates, and low-quartz rocks of ZЄn$_c$, and is rare in every other stratigraphic unit in the region.

The Calc-silicate Member is thickest at West Mountain (possibly over 300 meters); it thins dramatically to the north and appears to be less than 30 meters thick where it overlies the Wacke Member (ZЄn$_w$) of the "Ned Mountain Formation" (Fig. 4). In the southernmost area, at Pound Ridge, ZЄn$_c$ seems to contains only the K-feldspar-rich and quartz-plagioclase-biotite-garnet-graphite granofelses, amphibolite, and metawacke lithologies. Calc-silicate there appears limited to clinopyroxene-rich amphibolites. In the central area, at West Mountain, all lithologies are present and most are intimately interbedded. In the northern Peach Lake quadrangle, the thin ZЄn$_c$ member contains K-feldspar-rich quartzite interlayered with clinopyroxene-K-feldspar calc-silicate. Rocks identical to the sillimanite-bearing metawacke, quartz-plagioclase-biotite-garnet granofels and amphibolite seen in ZЄn$_c$ at West Mountain and Pound Ridge are restricted to the underlying Wacke Member in the northern Peach Lake quadrangle. Thus, the Wacke Member of the "Ned Mountain Formation" appears to be correlative with both the Volcaniclastic and much of the Calc-silicate Members of the southern Peach Lake quadrangle (Figs. 4 & 5).

"Ned Mountain Formation", Wacke Member (ZЄn$_w$). The Wacke Member of the "Ned Mountain Formation" (Stop 1C) overlies the Basal Member (ZЄn$_b$) in the northern Peach Lake quadrangle (Figs. 2 & 4). It contains metawackes of quartz-plagioclase-K-feldspar-biotite-garnet-sillimanite, quartz-plagioclase-biotite-garnet±K-feldspar granofelses, and both hornblende and cummingtonite (+hornblende±orthopyroxene) amphibolites. It is locally graphitic near the base, where it overlies graphitic granofelses and metasaprolite of ZЄn$_b$ (Stop 1C). Although it appears to be partly correlative with the Volcaniclastic Member of the "Ned Mountain", it seems to contain relatively little rhyolitic material. K-feldspar is minor or absent in most granofels layers, though some beds are K-feldspar rich. This is consistent with the northward decrease in unweathered rhyolitic material already observed within the Volcaniclastic Member.

While the Calc-silicate Member and the Wacke Member contain similar metawackes and granofelses, proportions of these rock types are very different. Granofelses are far more abundant in the Calc-silicate Member than metawackes, while the reverse is true in the Wacke Member. The two units appear to be shallow- and deeper-water equivalents: the shallow-water to subaerial ZЄn$_c$ contains interbedded calc-silicates, granofels, and saprolite, while the ZЄn$_w$ consists of basin-type sediments. Only after a deep basin had been filled, perhaps, could a shallow-water environment be established in the northern Peach Lake quadrangle and the thin calc-silicates of ZЄn$_c$ be deposited. The much higher volcanic input in the "Ned Mountain Formation" of the southern Peach Lake area may account for the longer period of shallow-water deposition there.

The Manhattan Schist and the Wacke Member may in fact be similar in age and analogous in origin. Hall (1968, 1979) long held that the Manhattan (units B and C) was a Cambrian unit allochthonously emplaced over Ordovician Walloomsac Formation (Hall's Manhattan A). The Manhattan has been correlated with the Cambrian Hoosac Formation (Rodgers, 1985), and the Hoosac, in turn, has been interpreted as rift-related deposits over Grenville basement (Stanley and Ratcliffe, 1985). The Wacke Member appears to have had a similar origin (Figs. 4 & 5). The Wacke Member, like portions of the Hoosac and unlike the Manhattan, is autochthonous: it is still in place over the basement on which it (and the Basal Member) were originally deposited.

STATUS OF THE LOWERRE QUARTZITE

The "Lowerre Quartzite" is the only unit of the Manhattan Prong previously recognized between Fordham Gneiss and Inwood Marble. Most lithologies of the "Ned Mountain", (e.g., the amphibolites, calc-silicates, quartz-plagioclase-biotite-garnet granofelses, metasaprolites, and metawackes), have all been previously assigned to either Fordham, Manhattan or Inwood (Prucha and others, 1968). Usually only the feldspathic sandstones or rare quartzite have been designated "Lowerre", although Hall and his students (for example, Jackson and Hall, 1982) included some schistose rocks. The sporadic nature, K-feldspar richness, and conformity of the "Lowerre" quartzites with underlying "Fordham" lithologies have been sources of confusion, and caused many workers in past years to deny the existence of a post-Fordham, pre-Inwood stratigraphic unit in the Manhattan Prong. Fluhr and Bird (1939) found that a pebbly quartzite seemed to grade into a sheared granite. Berkey (1907), Prucha (1956) and Scotford (1956) argued that the "Lowerre" was merely a sheared or quartz-rich portion of the Fordham. Prucha (1956), working in the Peach Lake region, concluded that the Fordham and Inwood were stratigraphically continuous. On the other hand, many workers (e.g., Norton and Giese, 1957; Norton, 1959; Hall, 1968; Alavi, 1976) found occasional outcrops of quartz-rich sandstone below the Inwood Marble.

Recognition that, at least in the Peach Lake area, the "Lowerre Quartzite" is not a basal sandstone unconformably overlying Grenvillian Fordham allows a resolution of this controversy. The diversity of rock types that belong to the "Ned Mountain Formation", and the fact that many at least superficially resemble other stratigraphic units, suggests that the unit very likely has gone unrecognized in other parts of the Manhattan Prong.

Placing the rocks of the "Lowerre Quartzite" within the expanded context of the "Ned Mountain Formation" makes their K-feldspar richness understandable. Previous workers have remarked on the enigmatic abundance of K-feldspar in correlative Cambrian sandstones like the Cheshire and Poughquag Quartzites. In the Lincoln area of Vermont, Tauvers (1982) found that while older rift deposits (Pinnacle Formation) contain abundant plagioclase and appear to be derived from local basement, the overlying Cheshire Quartzite contains K-feldspar. He suggested a change to a "cratonal" source for these sediments. Aaron (1969) noted that the (unmetamorphosed) Hardyston Quartzite of New Jersey-Pennsylvania is rich in fresh K-feldspar and surprisingly poor in plagioclase. Plagioclase predominates over K-feldspar in Grenville gneisses of the Reading Prong (Aaron, 1969), as it does in the Manhattan Prong. The erosion of K-feldspar rich (crystal?) tuffs and associated felsic volcanic edifices of the Volcaniclastic Member of the "Ned Mountain Formation" provides a source for the K-feldspar so characteristic of the quartzites underlying the passive margin dolomite sequence.

INFERENCES FROM THE "NED MOUNTAIN FORMATION": RIFT-STAGE GEOLOGICAL DEVELOPMENT OF THE NORTHEASTERN MANHATTAN PRONG

The varied lithologies of the "Ned Mountain Formation" present a picture of a dynamic and rapidly evolving depositional environment. Together with the bimodal nature of its volcanic rocks, the abundance of clastic material, abruptness of facies changes, and its stratigraphic position (underlying the stable shelf deposits of the Inwood Marble), the "Ned Mountain Formation" appears to be the product of a rift environment (Fig. 5). The "Ned Mountain" resembles the late Proterozoic to Early Cambrian Chilhowee Group of Virginia in containing both rhyolitic volcaniclastics and basalt flows (Simpson and Eriksson, 1989). But the "Ned Mountain", like the Hoosac and Pinnacle Formations of New England, (Stanley and Ratcliffe, 1985) also contains marble, particularly near the top of the rift sequence.

The post-Grenvillian depositional history of the northern Manhattan Prong can be summarized this way:

1. As rifting is initiated, a Late Precambrian erosional surface forms over the Fordham Gneiss. Volcanic activity begins. Thin rhyolitic and basaltic beds are laid down. Aluminous saprolite develops in higher elevations; weathered volcanic debris and saprolite is washed into stagnant lakes (ZЄn_b).

2. A relatively deep basin develops in the northern Peach Lake region. It receives immature sediments from eroded Fordham basement and basaltic flows. An acid volcanic center is established at Pound Ridge, resulting in thick rhyolite deposits. In the intervening area, shallow-water weathered volcaniclastic sediments are deposited (ZЄn_v and ZЄn_w).

3. While deep-water deposition continues in the northern Peach Lake quadrangle, in the south episodic shallow-water deposition and subaerial exposure occurs. An interbedded sequence consisting of limestone, arkose, volcanic ash, and minor wacke (ZЄn_c) is laid down on top of ZЄn_v. Eventually, the deep-water basin is filled, and the shallow-water calc-silicates and arkoses of ZЄn_c overlie ZЄn_w in the north as well.

4. A stable shelf environment is established. Algal dolomites (which, when metamorphosed, produce magnesian marbles) are (conformably?) deposited over the ZЄn_c member.

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ROAD LOG FOR THE STRATIGRAPHY OF THE NORTHEASTERN MANHATTAN PRONG, PEACH LAKE QUADRANGLE, NEW YORK - CONNECTICUT

The Starting Point for the field trip is the Rest Area on east-bound Route I-84 located 4 miles east of the intersection of I-84 and I-684 (Fig. 1). If you are approaching from the east (on the west-bound lane of I-84), then you need to overshoot and to do a U-turn at the Sawmill Road exit in order to reach the Rest Area.

The locations of the stops are shown on several maps (Figs. 1, 2, 6, & 7) and the schematic cross section (Fig. 4).

Cumulative Mileage	Mileage from last point	Route Description
0.0	0.0	Start from Rest Area. Log starts from the entrance to the service road. Take service road onto east-bound route I-84.
2.3	2.3	Turn off right onto Route 7 south.
2.7	0.4	Turn off right to Park Ave. exit.
3.1	0.4	Turn left (southwest) at traffic light onto Backus Ave.
3.8	0.7	Traffic light. Continue straight.
4.2	0.4	Stop sign. Turn right (west) onto Miry Brook Road.
4.7	0.5	Complex intersection. Go straight ahead -- bearing slightly LEFT onto George Washington Highway.
6.0	1.3	Stop sign. Turn left (south) onto continuation of George Washington Highway.
6.9	0.9	Bear left at Y-junction onto Old Stagecoach Road. Road becomes Bennetts Farm Road. Sharp turns.
7.7	0.8	Bear left (east) on Bennetts Farm Road.
7.9	0.2	Turn left (north) on INCONSPICUOUS little road called Sky Top Drive into a housing development.
8.0	0.1	Turn left at Y on a nameless road. Continue past "No Outlet" sign.
8.1	0.1	Turn right (east) onto North Shore Drive.
8.3	0.2	Park at the end of the road on the north shore of Lake Windwing.

STOP 1. STRATIGRAPHIC SECTION FROM FORDHAM GNEISS, THROUGH "NED MOUNTAIN FORMATION" (ZЄn_b, ZЄn_w, AND ZЄn_c), AND INTO INWOOD MARBLE

This stop entails a 1.6 kilometer hike, only part of it on trails, and some fairly steep slopes. There are several stations, so the stop will require some hours.

Traverse northwards (Fig. 6) up the hill, over the crest, and down onto the east-west trail (passing metawackes and granofelses of the ZЄn_w member as you climb). Turn and go east on the trail until you encounter a T-junction with a north-south trail. Follow this trail north for 0.6 km to a bridge over a northeast flowing steam. Turn west. Go 30 meters off the trail to the base of the hill slope. Station 1A.

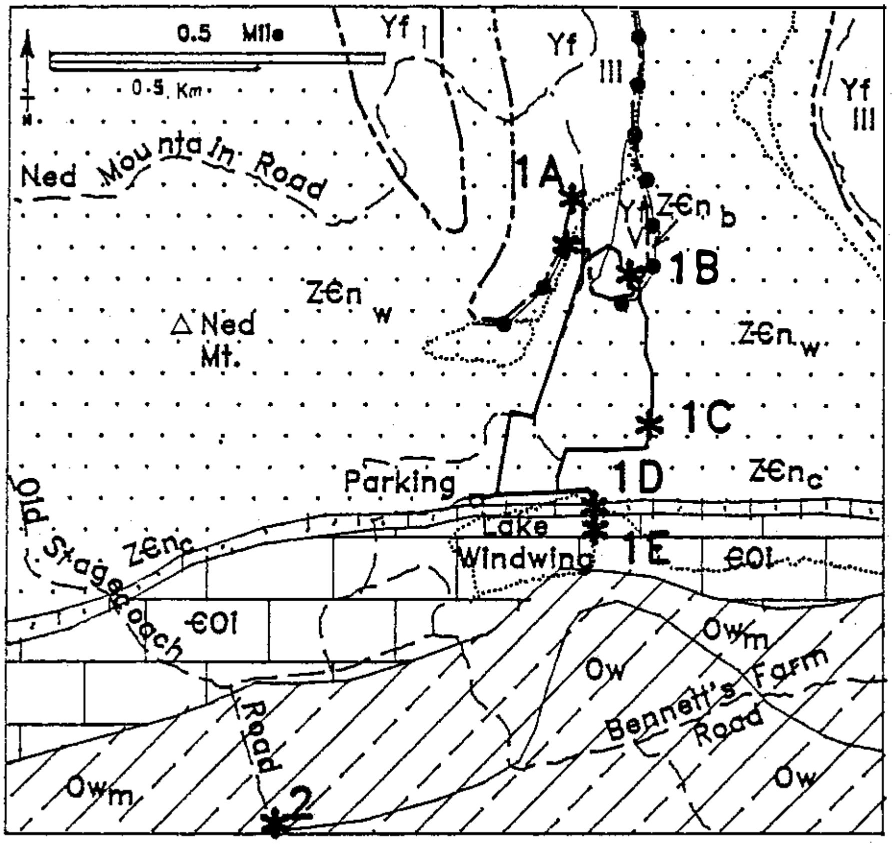

Figure 6.

Stops 1 and 2. Traverse is shown by heavy line. Roads are dashed. Streams and lakes are dotted. Other symbols are as in Figure 2.

Station 1A. Fordham Gneiss and overlying Basal Member of the "Ned Mountain Formation"

The Yf_{III} member of the Fordham Gneiss is exposed on this hill. It consists of well-layered and compositionally heterogeneous coarse-grained, orthopyroxene-bearing gneisses. The scale of compositional layering ranges from about 2 cm to a meter. Some layers are highly leucocratic, quartz-plagioclase-orthopyroxene-biotite-clinopyroxene±K-feldspar; dark layers are generally hornblende-rich. On close inspection, pitted and rust-stained orthopyroxenes can be seen on the weathered surface of the outcrop.

Here the Fordham largely retains its characteristic, poorly foliated Grenvillian texture. Locally, lineation defined by mafic minerals is evident. The effects of Taconian metamorphism can be seen in thin section: many orthopyroxenes are surrounded and embayed by cummingtonite and/or hornblende. Some pyroxene-bearing granite is present along the hill slope.

A number of small shear zones cut discontinuously across the gneisses. These seem to be related to an episode of post-Taconian shearing seen elsewhere in the northern Manhattan Prong. Age constraints from these areas suggest a Carboniferous age for the post-Taconian deformation (Brock and others, 1985; Brock and Brock, 1985 a & b).

After examining the Fordham, follow south along the cliff base for 60 to 100 meters to see the Basal Member of the "Ned Mountain Formation".

Here the Basal Member of the "Ned Mountain Formation" is a fissile, rusty-staining, graphitic granofels. The rocks are medium- to fine-grained, and contain quartz-K-feldspar-plagioclase-biotite-graphite±garnet. The tough Fordham gneisses form the crown of the hill, and the softer granofelses lie along its southern flank.

Biotite in the graphitic granofelses is concentrated into close-spaced (though discontinuous) streaks; as a result, the rocks tend to break into thin folia. This habit, and their K-feldspar-richness, distinguish the "Ned Mountain" granofelses from similar rocks in the Fordham and the Walloomsac. The graphitic, rusty-weathering granofels of the Fordham unit Yf_y contains no K-feldspar and little biotite. Walloomsac granofelses are typically quartz-plagioclase-biotite-graphite rocks containing little if any K-feldspar and breaking in a slabby fashion.

Fordham lithologies are truncated against the "Ned Mountain Formation". Where ZꞒn_b is first seen, it is in contact with heterogeneous, layered gneisses; following the unconformity ~30 meters southwest, largely leucocratic, homogeneous Fordham gneisses are against it; after another hundred meters large amphibolites lie at the unconformity; still further southwest, leuco- to mesocratic gneisses are in contact with the graphitic granofelses of ZꞒn_b. Fordham gneisses adjacent to the unconformity tend to show the effects of Taconian metamorphism and deformation more than they do elsewhere. They are richer in biotite and have a better-developed foliation.

After finishing with this station, cross back to the east over the old dam. (The dam stands above the stream and swamp to the south of the hill.) Retrace your steps along the trail southwards for approximately 100 meters to the junction with a branch trail that climbs up to the east. Follow it east for ~30 meters (Fig. 6). Then turn south off it to the outcrops of Station 1B.

Station 1B. Fordham Gneiss, Unit Yf_y

Here Unit Yf_y of the Fordham consists of well-layered, medium to coarse-grained, melanocratic to leucocratic gneisses. Plagioclase-quartz-hornblende-biotite-pyroxene±cummingtonite gneisses and amphibolite are present in the first outcrop. Rocks still showing the distinctive assemblage of YF_y, gar-net-clinopyroxene-plagioclase±orthopyroxene, can be seen in the outcrop further from the path. Partial replacement of this assemblage by hornblende (and of orthopyroxene by cummingtonite) is thought to have occurred during Taconian metamorphism. The assemblage has not been found in any rocks of post-Grenville age.

Next, proceed southeastwards through the bush looking for outcrops. When you reach the north-south trail marked with yellow dots, follow it southwards to the crest of the scarp overlooking Lake Windwing. En route you will see a good section through the metawackes, pelites, hornblende amphibolites and cummingtonite amphibolites of the ZꞒn_w member of the "Ned Mountain Formation".

Station 1C. Wacke Member of the "Ned Mountain Formation"

As you walk, you will first pass outcrops of coarse-grained K-feldspar-plagioclase-sillimanite-garnet-biotite-quartz±graphite schist of the Basal Member. The rocks are garnet-rich and contain prominent sillimanite trains; the contrast between the sillimanite-biotite-garnet and feldspathic segregations produces a pin-striped appearance. Metawackes of the Wacke Member, slightly higher in the section, have a similar pin-striped appearance but contain more quartz and less K-feldspar than the Basal Member.

A number of medium-grained granofelsic layers are present along the trail. These range from about 10 to 60 cm thick, and contain quartz-plagioclase-biotite-garnet±K-feldspar. Fine layering is often visible on close inspection.

Near the scarp several amphibolites are interlayered with the metawackes and granofelses. These include slightly greyish hornblende-cummingtonite-orthopyroxene bearing amphibolites and blacker orthopyroxene-free hornblende amphibolites.

The thick "pinstriped" metawackes, thin granofelses and hornblende amphibolites of the "Ned Mountain Formation" Wacke Member at this locality make it strongly resemble the Manhattan Schist. But in addition to the distinctive stratigraphic position of the "Ned Mountain", it can be distinguished from the Manhattan in several ways: a) while granofelses of the Manhattan contain little or no K-feldspar, those in the "Ned Mountain" in some places have substantial amounts; b) the Wacke Member is locally graphitic near its base, while the Manhattan contains no graphite; c) cummingtonite-bearing amphibolites have not yet been found in the Manhattan Schist; and d) bedding of the granofelsic layers in the Wacke Member thins towards the north, while no geographical variation is apparent in Manhattan Schist. At this locality, granofelses in the Wacke Member have similar thicknesses to those in Manhattan Schist, mostly between 5 cm and 1 meter. But about three kilometers to the north, granofels and hornblende-orthopyroxene amphibolite beds are both typically 1.5 cm to 8 cm thick, and 4.5 km to the north, many beds are ~1 cm thick. This thinning is interpreted to reflect a southerly provenance for the sediments of the Wacke Member (Figs. 4 and 5).

Getting down the scarp is somewhat tricky. Good exposures of migmatized metawackes of ZЄn$_w$ are present in the cliffs below, but for safety, it is better to follow the trail along the crest until it turns down. From the bottom of the slope, go to the spillway of Lake Windwing (at the lake's eastern end).

Station 1D. Calc-silicates, Arkosic Sandstones, and Pelite of the "Ned Mountain Formation, ZЄn$_c$ member

K-feldspar-rich quartzite and clinopyroxene-K-feldspar bearing calc-silicate are interbedded on the south side of the spillway. Beds range from 5 to 50 cm thick. A biotite-rich pelite is present on either side of the spillway. This outcrop displays the thin northern variant of the Calc-silicate Member, which overlies the Wacke Member of the "Ned Mountain Formation". Shearing and pegmatite intrusion thought to be of Carboniferous age has resulted in local development of muscovite in the pelites and tremolite in the calc-silicate.

Go 15 meters south. Scattered outcrops of white marble: Station 1E (Fig. 6).

Station 1E. Inwood Marble

The Inwood here consists of well-bedded, white and buff weathering calcitic marble. The outcrop at the lakeside contains a bed of clean quartzite. Buff-weathering marbles contain the assemblage calcite-forsterite-dolomite-phlogopite±periclase whereas white marbles contain calcite-dolomite-phlogopite±periclase. Although quite rich in calcite, these are magnesian marbles typical of the Inwood.

The Inwood contains more carbonate and less silica and K_2O than does the Calc-Silicate Member. It is also much less diverse lithologically. Marbles of the Calc-silicate Member of "Ned Mountain Formation" and Inwood Marble can be distinguished by their mineral assemblages (Fig. 3). Forsterite and phlogopite (occasionally spinel), ± clinopyroxene are typical constituents of the more magnesian, originally dolomitic Inwood. Clinopyroxene and K-feldspar are characteristic of both the low-magnesium Calc-silicate Member and Walloomsac marble.

Walk west 0.3 km on the trail along the north shore of Lake Windwing to the starting point of the traverse.

8.3	0.0	Leave Lake Windwing. Retrace route.
8.5	0.2	Stop sign. Bear right.
8.7	0.2	Turn right (west) onto Bennetts Farm Road.
8.8	0.1	Turn left (south) onto Old Stagecoach Road.
9.1	0.3	Pull off to right and park.

STOP 2. OUTCROPS OF WALLOOMSAC SCHIST AND MARBLE

Here (Fig. 6) we see Walloomsac marble that was unconformably laid down over the Inwood (Table 1). Small outcrops of Walloomsac marble lie on either side of the road. These consist of well-bedded, rusty-stained, graphitic marble; they contain calcite-quartz-plagioclase-K-feldspar-clinopyroxene ±phlogopite. Some coarse, late tremolite is present. Walloomsac marbles somewhat resemble calc-silicate rocks of the "Ned Mountain Formation", but differ from "Ned Mountain" in their distinctive rusty staining and in the abundance of graphite.

A few meters south on the west side of the road is a small outcrop of Walloomsac Schist. The Walloomsac here consists of a rusty-weathering, graphitic, quartz-plagioclase-biotite-garnet schistose granofels. K-feldspar-rich granofelses, typical of the Calc-silicate Member of the "Ned Mountain Formation", are never found in the Walloomsac.

9.1	0.0	Continue south. The road swings round to the east and becomes Aspen Ledges.
9.8	0.7	Park on Fox Drive on right. Walk east round the curve to see road cut of Walloomsac Schist.

STOP 3. CORDIERITE-BEARING WALLOOMSAC SCHIST

Slabby-breaking, rusty-staining, quartz-plagioclase-garnet-K-feldspar-sillimanite-cordierite graphitic schistose gneiss of the Walloomsac Schist outcrops here. More pelitic than at previous stop, the Walloomsac contains cordierite-sillimanite-garnet assemblages overprinted by K-feldspar-sillimanite-biotite. In thin section, garnets are rimmed by sillimanite against cordierite. The cordierites are rust-stained and obviously relict.

9.8	0.0	Continue east on Aspen Ledges.
10.1	0.3	Turn right (south) onto Bob Lane. The road swings to the east. (In Hartland Fm.)
10.4	0.3	Pull off on left beside road cut.

STOP 4. HARTLAND FORMATION AMPHIBOLITE AND GRANOFELS

Between Stop 3 and here, you have crossed Cameron's Line, the boundary between the rocks of the Manhattan Prong and the Hartland terrane (Fig. 2). Manhattan Schist, which elsewhere structurally overlies the Walloomsac, was cut out along this part of Cameron's Line. The Hartland was emplaced over the rocks of the Manhattan Prong early in the Taconian orogeny, and was later deformed along with them. At this outcrop, quartz-plagioclase-biotite granofels of the Hartland Formation is interlayered with hornblende-orthopyroxene±clinopyroxene amphibolite. Bedding ranges from 5 cm to 50 cm in thickness. The Hartland is distinguished from the Manhattan by its abundant amphibolites, its non-rusty, relatively garnet-poor granofelses, and its rhythmically interbedded schist and granofels sequences (meta-turbidites) not seen here.

A granite showing graphic intergrowth of quartz and K-feldspar and large books of biotite is also present at this outcrop. It contains no primary muscovite and is undeformed. It is thought to be late Taconian in age.

This completes a section from the Fordham Gneiss to the structurally highest rocks in the northern Peach Lake quadrangle. Next, we will examine a section in the southern part of the quadrangle.

10.4	0.0	Continuing east
10.5	0.1	Turn right (south) onto Knollwood Drive.
10.7	0.2	Forced right/bear right onto Twixt Hills Road.
10.9	0.2	Turn left (south) onto Pierrepont Drive. Down around hairpin bends. Road swings west past Lake Naraneka and is here called Barlow Mountain Road.
11.5	0.6	Turn left (south) at stop sign. Still on Barlow Mt. Road. (Right branch is Ledges Road.)
11.9	0.4	Turn right (west) at T-Junction. Still on Barlow Mt. Road. (Left branch is North Street.)
12.2	0.3	Turn left (south) onto Route 116. Tackora Trail.
13.8	1.6	Turn right (west) onto Saw Mill Hill Road.
14.4	0.6	Bear right (west) onto Rampoo Road.
14.8	0.4	Bear right (west) onto Oreneca Road.
15.0	0.2	Turn right (northeast) onto Sharp Hill Road.
15.2	0.2	Park at end of road.

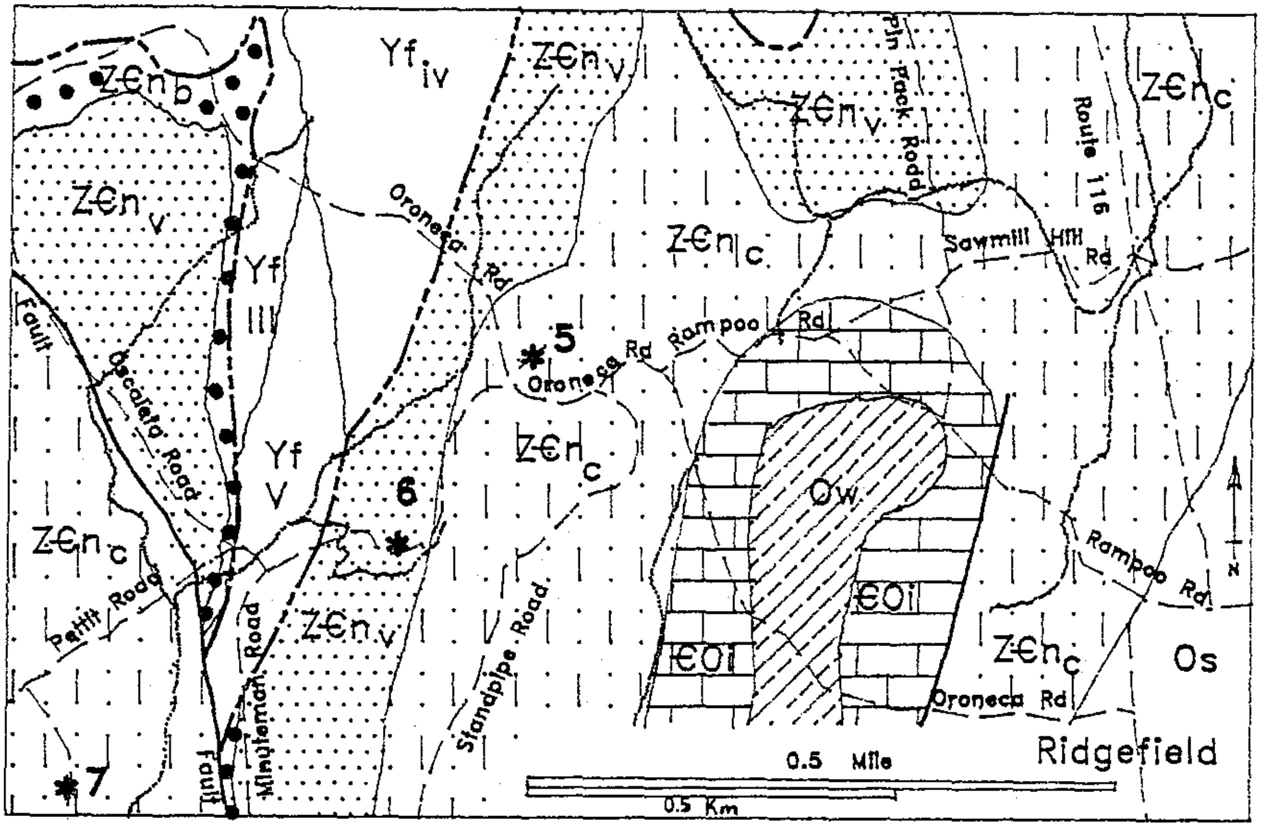

Figure 7. Stops 5 to 7. Streams are dotted; roads are dashed. Other symbols as In Figure 2.

STOP 5. CALC-SILICATE MEMBER OF THE "NED MOUNTAIN FORMATION", SOUTHERN SECTION

These outcrops are on private property. If you come by yourself, ask permission from the owners before looking. Outcrops are located at the end of the road and on the road's north side, by the driveway going north up the hill. Beware of poison ivy.

Inwood Marble lies in the bottom of the valley you have just driven across (Fig. 7). You are on the east limb of an F_2 antiform, and will continue going down stratigraphically as you proceed west. Here in the southern portion of the Peach Lake quadrangle (Fig. 1), the Calc-silicate Member of the "Ned Mountain Formation" is much thicker than at Lake Windwing. At this locality, white-and-green clinopyroxene-bearing calc-silicates and marbles are interlayered with greyish, laminated, quartz-K-feldspar-plagioclase-biotite granofelses and hornblende amphibolites. Retrogressive tremolite and epidote is locally present in calc-silicate layers. The characteristic ribbing on the weathered surface of the calc-silicates reflects variations in bed-by-bed carbonate content. Some granofelsic layers are clinopyroxene-hornblende-bearing, but rich in K-feldspar whereas others are plagioclase- and biotite-rich. Modal K-feldspar in the granofelses varies from 20% to 70%, while quartz ranges up to about 60%. The granofelses show a faintly developed linear fabric.

NOTES