GENERAL STRUCTURE AND ORDOVICIAN STRATIGRAPHY FROM THE MARLBORO MOUNTAIN OUTLIER TO THE SHAWANGUNK CUESTA ULSTER COUNTY, NEW YORK

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INTRODUCTION

The Lower Wallkill Valley lies within the western portion of the Appalachian fold belt and is approximately 70 miles (43.5 km) northwest of New York City (fig. 1).

Within the study area the eastern side of the valley is flanked by Ordovician flysch deposits forming the Marlboro Syncline (Waines, 1986). On the western side is the Shawangunk Mountain escarpment capped by the Upper Silurian Shawangunk Conglomerate.

The Middle to Late Ordovician Martinsburg Formation forms the bedrock of most of the Lower Wallkill Valley while the bedrock on the eastern side is underlain by Middle to Late Ordovician Quassaic arenites. Most of this is usually blanketed by Wisconsinan till or alluvial deposits derived from the Wallkill River (Connally and Sirkin, 1967).

Because of structural complexities, infrequent fossils, and lack of stratigraphic markers it is difficult to establish close lithologic correlation within the Martinsburg Formation.

Previous attempts to determine and depict the structure and stratigraphy of the area by Holzwasser (1926), Rickard(1973), and Waines et al. (1983) have not been entirely successful. An increase in bedrock exposures as a result of recent road construction together with geologic data acquired from the Delaware West Branch Aqueduct (City of New York Board of Water Supply, 1938, 1939), Catskill Aqueduct (Board of Water Supply, 1905-1918), and logs from three wild cat wells (Susi, Modena, Minnewaska) have

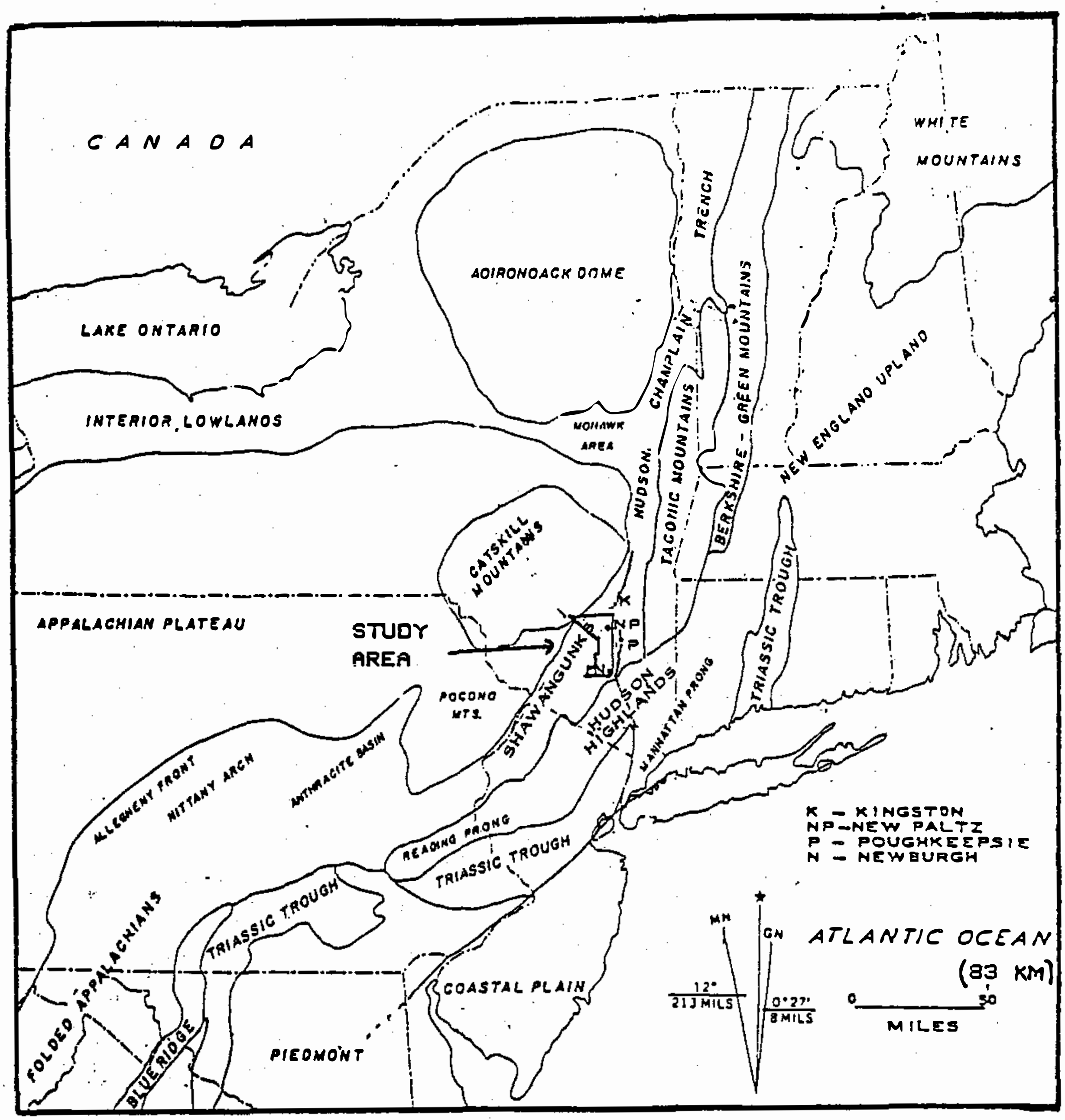


Figure 1

REGIONAL SETTING OF STUDY AREA

(Adapted from H.A. Meyerhoff, 1963, in NYSGA Guide Book 35th Ann. Meeting, p. 17, Fig. 1) enabled the construction of a composite northeast-southwest structure section (Kalaka, 1985, fig. 23). This section extends from the center of the Marlboro Mountains near Lloyd, New York westward through the Martinsburg Formation in the eastern central, central, and western portions of the valley continuing under the Shawangunk Mountains almost to Wawarsing, New York (figs. 2 and 3).

The section reveals three major structural domains (east to west): (1) a monoclinal, southeast-dipping domain in which an arenite facies shales to the west and southwest (west limb of the Marlboro Syncline); (2) a complex domain involving mostly shales (central portion of the Wallkill Valley); (3) an open fold domain involving mostly shales (western portion just east of and under the Shawangunk Cuesta) (Kalaka, 1985, fig. 24), (fig. 2).

STRATIGRAPHY

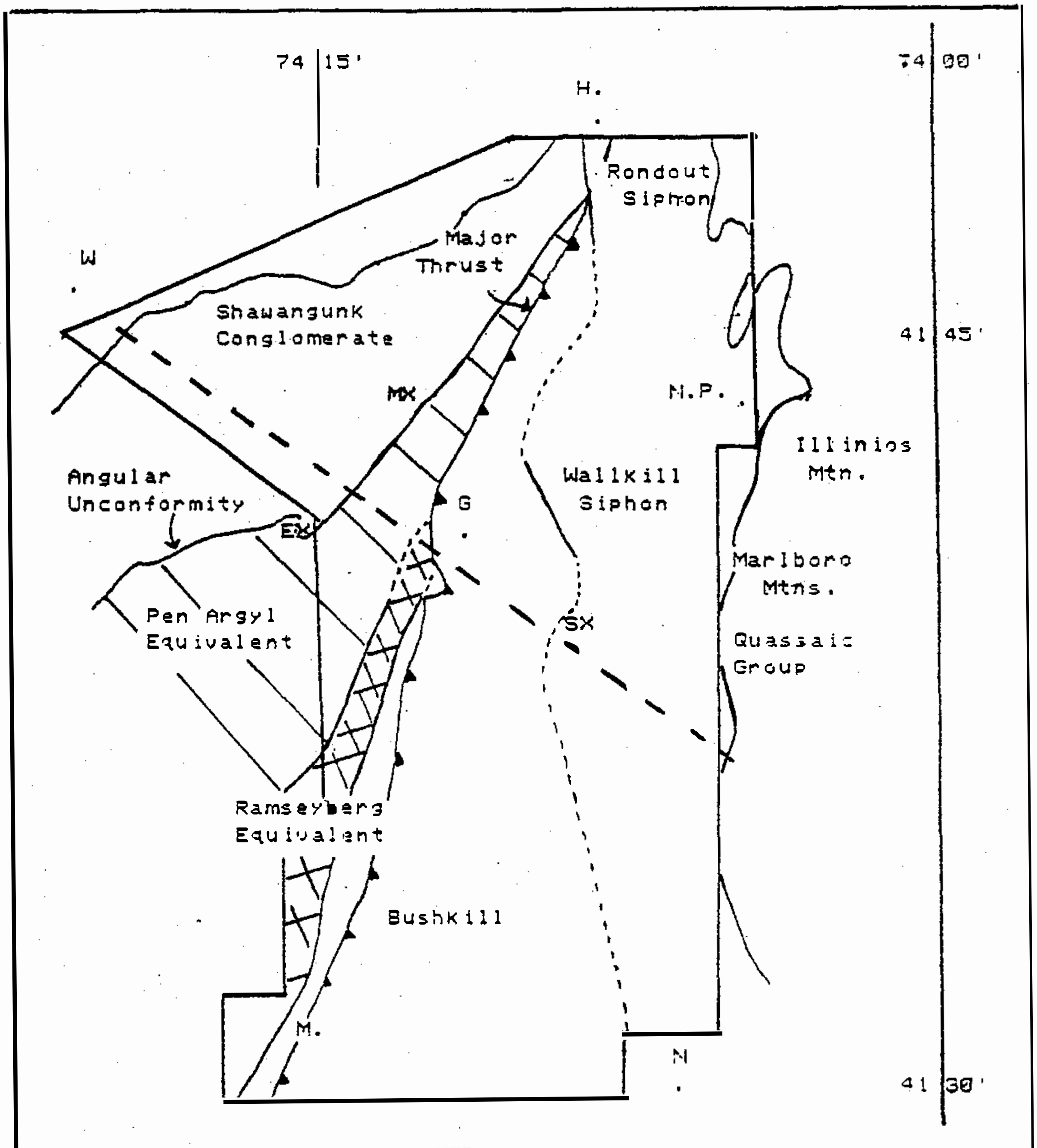
The Lower Wallkill Valley is underlain by three main stratigraphic units (Kalaka, 1985, fig. 14). In the north-south trending Marlboro Syncline the 10,000 foot (3048m) Ordovician Quassaic Group outcrops as medium bedded sub-graywackes and quartz arenites (Waines et al., 1983; Waines, 1986). In the eastern central, central, and western portion of the valley the Bushkill Shale (lower member of the Martinsburg Formation) crops out. In the western portion, possible stratigraphic equivalents of the middle and upper Martinsburg are overlain by the Shawangunk Conglomerate with angular unconformity.

<u>SHAWANGUNK CONGLOMERATE</u> On the western margin of the valley the Shawangunk Mountain Cuesta is capped by a late Silurian, white, vein quartz conglomerate that is in angular unconformity with the upper portion of the Martinsburg Formation. Thickness ranges possibly between 600 and 300 feet (92m) in the study area (Waines and Sanders, 1968).

<u>QUASSAIC GROUP</u> This group is late Medial to medial Late Ordovician in age. It consists of a 10,000 foot (3048m) sequence of arenites which have been subdivided into five formations which, top to bottom, are: <u>Creeklocks</u> (1410 feet, 430m), <u>Rifton</u> (2509 feet, 765m), <u>Shaupeneak</u> (2115 feet. 645m), <u>Slabside</u> (2214 feet, 675m), and <u>Chodikee</u> (1640 feet, 500m) (Waines, 1986). The group occurs as an outlier occupying the Marlboro Syncline with the east limb of overturned arenites determining the trace of the Marlboro Mountains (Waines, 1986). To the west and southwest the lowermost three formations appear to grade rapidly into the Bushkill Member of the Martinsburg Formation.

<u>MARTINSBURG FORMATION AND EQUIVALENTS</u> The eastern central, central and western portions of the valley are underlain by Medial to Late Ordovician Martinsburg Formation. This unit (composed primarily of dark gray shales and siltstones and less frequent arenites) has an estimated maximum thickness of about 12,000 feet (3659m) (Kalaka, 1985). To the east it appears to grade into the lower Quassaic arenites and to the west it appears to represent lateral facies of the middle and upper units of the Martinsburg (Ramseyburg and Pen Argyl).

<u>BUSHKILL SHALE</u> The lower member of the Martinsburg Formation (Drake and Epstein, 1967) consists of laminated to very thin bedded, dark bluish to dark medium gray shale (low grade slate) that weathers medium to very light gray to yellowish brown. The shale contains minute silty laminae weathering yellowish brown. Weathered laminae often contrast with the blue gray of the matrix and



REGIONAL GEOLOGIC MAP

FIGURE 2A

Legend

H - High Falls M - Montgomery
N.P. - New Paltz G - Ganagote
N - Newburgh W - Wawarsing

Scale: 0 — 4 miles (6.7 KM)

Catskill Aqueduct - - - - - - - - - - - -
Delaware Aqueduct — — — — — —

WELL LOCATIONS

Minnewaska #1	MX
Village Of Ellenville #1	EX
Susi Well	SX

AFTER KALAKA, 1985, FIGURE 14

are frequently enhanced by weathering. Sedimentary features most commonly encountered are graded bedding in silt and clay couplets, and cross-laminations in the silty laminae. Thicknesses vary from 2,000 feet plus (610m plus) below the Quassaic arenites (Waines et al., 1983) although where the Quassaic grades to shale the thickness may increase by as much as 6,560 feet (2000m) (Waines, 1986).

Generally the Bushkill Shale appears unfossiliferous, but a limited number of fossil locations have been determined.

RAMSEYBURG EQUIVALENT What is thought to be a lateral equivalent of the middle graywacke-bearing Ramseyburg Member of the Martinsburg Formation crops out just west of Montgomery and continues northeastward through the study area where it shales out and/or is terminated by a regional thrust. Although the Ramseyburg equivalent appears to have been traced by Offield (1967) across the Goshen 15 minute Quadrangle as the Austin Glen no authors have traced it directly to the Delaware Water Gap where the type location crops out (Drake and Epstein,1967). Because of its relative position between more shaley units above and below and its 200 foot plus (61m plus) thickness in the Goshen Quadrangle it is thought to be equivalent to the Ramseyburg.

In the study area the Ramseyburg Equivalent occurs as a sequence of alternating beds of dark low grade slates and shales and light gray, light brown to yellowish brown weathering, thin- to thick-bedded silty subgraywacke to quartz arenites. The graywacke occurs in beds that range from less than ¼ foot (0.1m) to 6 feet (1.8m) in thickness(averaging about 3 feet (0.9m)), and appear to comprise less than 15% of the sequence.

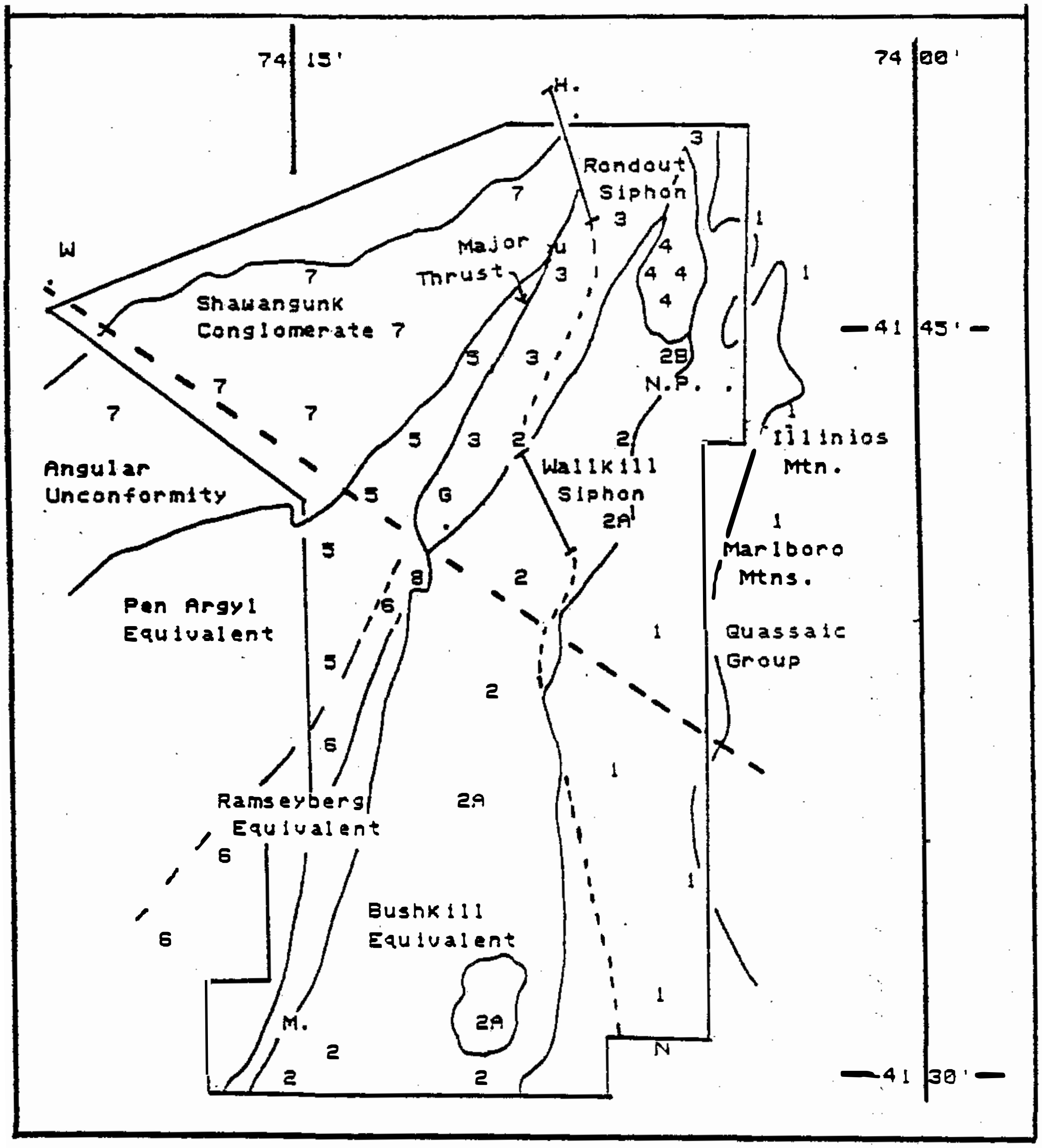
A flow cast-bearing interval can be traced in exposures from just west of Montgomery northeastward into the Shawangunk Kill. If it were not for the identification of this interval which can be projected into the Shawangunk Kill location from the southwest, the laminated shales and siltstones of the Ramseyburg Equivalent would be virtually indistinguishable from those of the Bushkill or Pen Argyl Equivalents. The contact with the overlying Pen Argyl Equivalent is probably gradational with the siltstones and graywacke bands thinning upward. No fossils were observed in the Ramseyburg Equivalent.

The estimated thickness of the Ramseyburg Equivalent in the Ellenville Well is 1600 feet (488m) and 600 feet (183m) in the Minnewaska Well (Kalaka, 1985, Table IV), (fig. 2).

The Shawangunk Kill may expose no more than 100 feet (30m) of graywacke-bearing strata, but the unit appears to thicken to the southwest because Offield (1967) estimated a thickness of about 4000 feet (1219.5m) south of the study area.

PEN ARGYL EQUIVALENT In the western portion of the valley the Martinsburg Formation consists of laminated shales and siltstones and some subgraywackes.

Siltstone layers range from 1/8 inch to 1-2 feet (0.6m), more commonly between 1/8 inch and ½ foot (0.2m). The sands and siltstone typically weather a buff color. A fresh shale surface is medium dark gray with a bluish cast weathering dark gray or black. Because of insufficient exposures



STRUCTURAL DOMAINS OF THE STUDY AREA

AFTER KALAKA, 1985, FIGURE 24

Legend

N.P. - New Paltz G - Ganagote

N - Newburgh W - Wawarsing

H - High Falls M - Montgomery

Catskill Aqueduct ------------

Delaware Aqueduct — — — — — —

Scale:

0 4 miles

(6.7 KM)

MAJOR STRUCTURAL DOMAINS

Subdomains

(I) 1 Monoclinal SE Dip

(II) 2 Central Complex

2A Open Fold

2B Imbricated

3 SE Dip Imbricated

4 Open Fold East Dip

(III) 5 Open Fold

6 Northwest dip

7 Open Fold Covered

8 Overturned East Dip

FIGURE 2B

it is virtually impossible to develop an acceptable stratigraphic column at present. No fossils were found in the observed outcrops.

An average thickness estimated from the Ellenville and Minnewaska Wells using gamma logs is about 6500 feet (1982m) for this unit (Kalaka, 1985, Table IV). This thickness is comparable to the thickness estimated by Drake and Epstein (1967) for the Pen Argyl member.

STRUCTURE

Except for the studies of Holzwasser (1926) which resulted in four structure sections across or near the Lower Wallkill Valley, few subsequent studies have been attempted, presumably because of the assumed complex structure within the valley (Kalaka, 1985, figs. 5-11).

Recent field data, supplemented with data from the Catskill and Delaware Aqueducts, have lead to the recognition and delineation of structural domains and new structural conclusions in a second approximation of a geologically complex region.

The area, centered on the Wallkill Anticlinorium ('Neelytown' of Rickard, 1973), can be divided into three major structural domains from east to west: (1) Monocline (Southeast Dip), (2) Central Complex, (3) Open Fold (Kalaka, 1985, fig. 24).

<u>Monoclinal (Southeast Dip) Domain</u> The eastern limb of the Wallkill Anticlinorium is represented by east-dipping strata which project into the western limb of the Marlboro Syncline and involve a possible composite 17,000 feet (5183m) (but more likely 12,000 feet (3660m)) of Bushkill and Quassaic sediments.

This domain is generally located between the Marlboro Mountains and Interstate 87 from the Rosendale-Dashville region to the southern tip of the Marlboro Mountains just north of Newburgh (fig. 2A).

Exposures representative of this domain occur along and in the vicinity of Route 299 east of New Paltz.

<u>Central Complex Domain</u> The axis of the Wallkill Anticlinorium which is masked by a complex of imbricate, east-dipping slices is located approximately along the course of the Wallkill River. The imbricate domain occurs along the crest of the anticlinorium and extends from Interstate 87 west to a major northeast-southwest trending thrust (figs. 2A, 2B). Three kinds of subdomains occur within this region: (1) highly complex, (2) east-dipping imbricated, (3) open folded.

Detailed mapping within the complex domain requires a large scale approach because the size of the subdomain inferred within the Wallkill Siphon are estimated to vary from 400 feet to 2800 feet (12m to 853.7m) in width (Kalaka, 1985m fig. 20; Kalaka and Waines, 1985). Detailed surface mapping is inhibited by glacial cover which masks a major portion of the bedrock within the Lower Wallkill Valley. It is unlikely that an entire subdomain is exposed anywhere within the valley (Kalaka, 1985).

The complex domain is abruptly terminated on its western margin by a major northeast to southwest trending, east-dipping thrust. This thrust may represent a sole fault projecting upward and westward off the surface of the Wappingers Carbonates on the east limb of the Wallkill Anticlinorium (fig. 3). This thrust may have formed during Acadian or later time in response to thrusting of the competent Quassaic arenite mass in the core of the Marlboro Syncline westward into the thick, less competent Bushkill Shales along the crest of the Wallkill Anticlinorium. Further evidence of the major thrust is a 2000 foot (610m) sequence of southeast-dipping, overturned strata in the lower reaches of the Shawangunkill near Tuthilltown. These strata, remarkable in their thickness and attitude, appear to have been overturned in response to overriding along the major thrust. Exposures of upper plate material occur nearby on Route 44-55.

No attempt has been made to determine the extent and nature of offset along the thrust because of lack of stratigraphic markers.

Open Fold Domain West of the major thrust there exists a domain of open folds and relatively minor faults which can be divided into two subdomains: one which is exposed to the east of the Shawangunk Cuesta, and one existing beneath Silurian cover. Structure of the latter was revealed mostly in the Delaware West Branch (City of New York Board of Water Supply, 1938, 1939) and Catskill Aqueduct Tunnels (Board of Water Supply 1905-1918) (Kalaka, 1985, figs. 18,20).

Field observations in the Trapps region (Route 44-55) in addition to the Delaware Aqueduct tunnel data indicate that the fold amplitudes and wave lengths to the east of the cuesta decrease westward beneath Silurian cover (Kalaka, 1985, figs. 10, 21). Although the detailed structure of the Silurian strata was not worked out the general attitudes of the beds appear to be reflected in the general slope of the land surface. Consequently, the Ordovician structure beneath Silurian cover appears to have much greater dimension than the Silurian folds and faults generated in the Acadian or later orogeny. Though variable, wavelengths in the Ordovician folds are about 2000 feet (610m) or smaller in the Rondout Pressure Tunnel and average 1400 feet (427m) to 6000 feet (1829m) or larger in the Delaware West Branch Tunnel (Board of Water Supply, 1905-1918; City of New York Board of Water Supply, 1938m 1939). For these reasons it appears the Ordovician structure is largely Taconian in origin with relatively minor 'Acadian' modification in the open fold domain.

Waines and Sanders, 1968 (figs. 1, 2 and Tables 1, 2) may have anticipated the open fold domain in determining Pre-Silurian Ordovician bedding attitudes in locations 11 through 15 of their paper. Paleodips (16 degrees or less) and dip direction variations (southwest, northwest, northeast, west and east) indicate a region of broad, open, gently plunging folds in the open fold domain. This domain originally may have extended to the east or northeast in Waines and Sanders locations 8, 9A, 9B, and 10 where Ordovician paleodips did not exceed 30 degrees and were inclined to the northwest, southwest, and southeast, indicating somewhat tighter folding. The latter locations lie within the imbricate domain but Pre-Silurian attitudes at the unconformity do not appear to have been affected by imbrication. It may well be that prior to the development of the imbricate domain the Ordovician open fold domain extended further east onto a less complex anticlinorium.

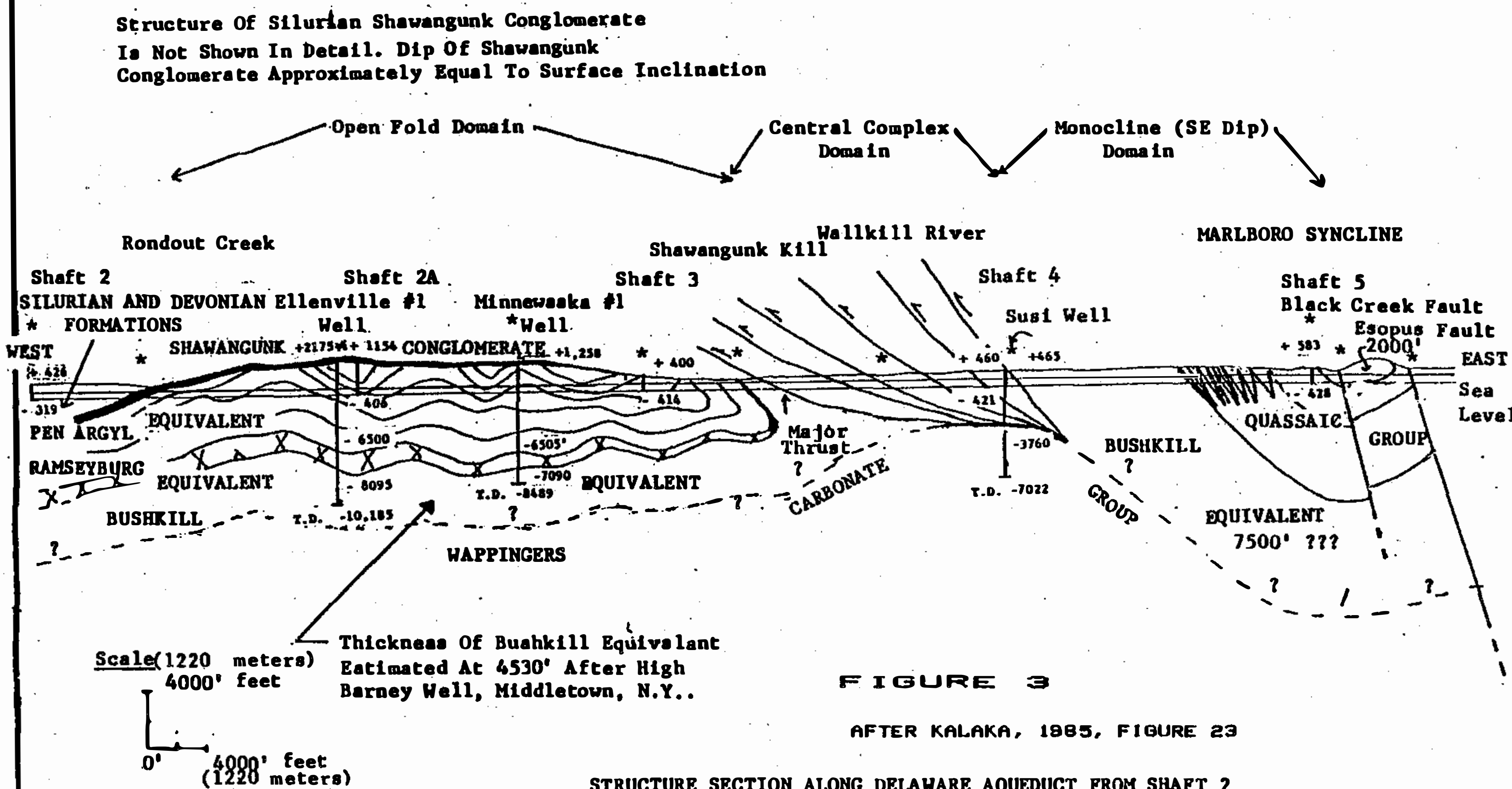


FIGURE 3

AFTER KALAKA, 1985, FIGURE 23

STRUCTURE SECTION ALONG DELAWARE AQUEDUCT FROM SHAFT 2 (RONDOUT CREEK) TO SHAFT 5 (MARLBORO SYNCLINE)

KEY

* PROJECTED POSITION OF FEATURE ABOVE NOTE ESPECIALLY PROJECTION OF WELL BORINGS, SEE FIGURE 2B

Although post-Silurian faulting has been recognized in the open fold domain, especially in the Delaware Aqueduct (Bird, 1943, fig.8), its nature is not well understood and the displacement appears to be relatively minor. Pre-Silurian faults probably occur also, but again appear to have had relatively minor effects.

CONCLUSIONS

On the basis of field observations augmented by data from the Catskill and Delaware Aqueducts and data from four deep wildcat wells (Ellenville #1, High Barney, Minnewaska #1, and Susi #1) a new structural and stratigraphic interpretation of the Middle Ordovician shales and sandstones of the Lower Wallkill Valley has been developed. Rather than a region of general isoclinal folding as envisioned by Holzwasser (1926, Plate 1) and depicted by Sandborn after Berkey (1950), the area appears to be subdivided into three major northeast-southwest trending structural domains which involve the Martinsburg Formation and Quassaic Group.

The easternmost domain is represented by monoclinal southeast-dipping strata (shales and arenites) of the western limb of the Marlboro Syncline. This domain includes Bushkill shales which interfinger with Quassaic arenites (Waines, 1986), (fig. 3).

A central complex domain consisting of imbricated east-dipping thrust slices with highly disturbed to open folded subdomains is located along the Wallkill Anticlinorium axis (Kalaka, 1985, fig. 24; Kalaka and Waines, 1986).

A major thrust appears to border the western margin of the complex domain. The thrust extends southward through the study area transecting the Catskill and Delaware Aqueducts. The motion along the thrust appears to be 'Acadian' because the thrust cuts through the Silurian and Devonian strata located on the northwestern border of the Lower Wallkill Valley.

The domain west of the thrust is characterized by open folds and minor faults. Tunnel and field data within this domain indicate that fold amplitudes generally decrease and wavelengths increase westward beneath Shawangunk Conglomerate cover.

Conclusions would be incomplete without reference to the Wallkill Siphon located within the complexly imbricated domain. Data suggest subdomainal entities which range from 800 feet (244m) to 2700 feet (823m) in width and indicate the size of the subdomains which can be expected within the valley (Kalaka, 1985, fig. 20; Kalaka and Waines, 1985).

If the present structural interpretation of the Wallkill Siphon is correct, mapping of subdomains within the imbricate zone using present geological techniques may be futile because of extensive glacial cover and the complex structure within the subdomains themselves. Were it not for the Catskill and Delaware Aqueduct data and the wildcat well information, the structural and stratigraphic interpretations presented here (fig. 3) would have been much more difficult, if not impossible, to develop.

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ROAD LOG AND STOP DESCRIPTIONS

Cumulative Mileage	Miles Between Points	Remarks
---	0	Enter NY 299 bearing right from NYS Thruway Exit 18 at New Paltz and proceed east.
4.0	4.0	Turn left (north) onto North Riverside Road.
4.15	0.15	Turn right onto Janewood Road and proceed to NY 299. Shale near telephone pole on left side of road is probably allochthonous Normanskill on the east side of the Esopus Thrust.
4.4	0.25	Turn right (west) onto NY 299.
4.5	0.1	Crossing buried Esopus Thrust.
4.7	0.2	Pull off highway and park next to cliff on right.

STOP #1. Here we are in middle third of Chodikee Formation (Stroter, 1983) the uppermost unit of the Quassaic Group. We are located in the east limb of the Marlboro Syncline. The age of these autochthonous strata is Late Ordovician. Beds are vertical to slightly overturned to the west. Continue west on NY 299.

4.8	0.1	Bridge over Black Creek fault where east limb of Marlboro Syncline has thrust westward over west limb of syncline.
5.05	0.25	Park along roadside next to outcrop.

STOP #2. Here is a more shaley version of the Chodikee Formation. Fossils include brachiopods and highly deformed cryptolithids. Strata typically dip east. Continue west on NY 299.

We will be moving down section for the next 2.1 miles and the normally arenitic formations in the Quassaic beneath the Chodikee are shaling out to the southwest.

5.60	0.55	Outcrop of Slabside Formation (?) on right.
6.65	1.05	Shaupeneak or Rifton Formation in road cut. This is the last exposure in the east-dipping domain on NY 299. Continue west.
8.10	1.45	Bridge over NYS Thruway. Entering eastern margin of complex domain.
8.2	0.1	Turn right (north) onto North Putt Corners Road at traffic light.
8.5	0.3	Turn left onto Henry Dubois Drive and proceed west.

9.35	0.85	Stop on the right as near this point as is safe and return on foot.

STOP #3. Here is a typical example of complex domain strata in the road cut on the north side with a good east-west sectional view. The strata are Medial Ordovician Bushkill shales and siltstones. Continue west downhill.

9.7	0.35	Stop; turn left onto NY 32. Proceed to second traffic light.
10.05	0.35	Turn right at light onto Main Street (NY 299) and proceed west.
10.25	0.2	Turn left (south) onto Water Street just before bridge over Wallkill River.
10.35	0.1	After stop, bear right onto Plains Road.
10.5	0.15	Bushkill outcrop on left.
10.6	0.1	Park in area on right and walk back over small bridge to outcrop on east side of road.

STOP #4. Here, beneath the poison ivy, are deformed shales and siltstones with east-dipping cleavage. Again, these appear to be Bushkill and the exposure occurs near the center of the complex domain. Return to cars and drive back to NY 299.

10.95	0.35	Turn left onto NY 299 across bridge over Wallkill River and head west across Wallkill River floodplain.
11.3	0.35	View of Shawangunk Cuesta at 12 o'clock.
11.9	0.6	Bear left onto Libertyville Road and proceed. Roadcuts observed over next 2.6 miles are in the complex domain. Stay on Albany Post Road.
19.25	7.35	Stop and turn left (east) onto Rt. 44-55.
19.8	0.55	Bridge over Wallkill River.
19.9	0.1	Turn hard right onto Farmers' Turnpike and proceed.
20.0	0.1	Park on right next to large blocks of Shawangunk conglomerate.

STOP #5. Extensive outcrop occurs at base of hill along river. Predominantly east-dipping argillites are involved in some folding and faulting. A foundation of an old covered bridge is observable. Here is another aspect of the complex domain. The strata are apparently Bushkill. No fossils have been found. Return to Rt. 44-55.

20.05	0.05	Turn left at stop sign onto Rt. 44-55 and proceed west.
20.7	0.65	Turn left onto Albany Post Road.
20.95	0.25	Bridge over Shawangunk Kill. Park in

open area on left side of road beyond bridge. Walk back over bridge to Tuthilltown Gristmill and assemble outside Gristmill store.

STOP #6. This is a hiking stop and we have been given special permission by the owner of the mill to walk across the property along the north bank of the Shawangunk Kill. Please stay with your leader and do not wander.

The first phase of the hike is about 1100 feet to a concrete dam across the Shawangunk Kill. On the far side of the stream and on the near side, when water is low, one can see an overturned section of east-dipping interlaminated siltstones and argillites which aggregate some 2000 to 2500 stratigraphic feet.

As far as we can tell, there is little faulting other than bedding plane dislocations and the sequence does not appear to belong in the complex domain. The differences between these strata and those at the next stop are noteworthy.

No samples in the dam area, please.

Proceed upstream from the dam along the berm of an abandoned canal. Watch out for woodchuck holes in the berm. They can be treacherous (the holes - not the woodchucks).

Proceed about 1,000 feet upstream from the dam to a point where a large hill on the north side of the stream closes to the stream. Here are numerous arenite layers in the shales, some up to a foot or so in thickness. These arenites are also overturned, dipping east as can be seen by flow structures on the basal bedding planes. This sequence seems to occur at the top of the argillite and silt sequence. The arenites can be traced southwestward into an ever-thickening arenite-shale sequence which seems to approximate the position of the Ramseyburg member in the Martinsburg Formation much further south. The augillite-silt sequence is most likely upper Bushkill if the foregoing is correct. This sequence in the Shawangunk Kill was first noted by Paul Kopsick (1977). Return to vehicle(s). Turn right out of parking area and return on Albany Post Road to Rt. 44-55.

20.3	0.3	Turn left onto Rt. 44-55 and park immediately in available space on right.

STOP #7: Walk uphill (west) along one side of highway and return , walking down other side. This extensive road cut is in the Bushkill shale and strata generally are right side up and dip east, but faulting and some drag folding suggest imbricate thrusting. This exposure is thought to represent a portion of the upper plate thrust over the lower plate exposed at Stop #6. A chance rockfall in this cut yielded an extensive fauna including bivalvia, articulate and inarticulate brachiopods, cryptolithid trilobites, graptolites, gastropods and burrows. Weathering rapidly

reduces the shale to fine rubble. Return to vehicle(s).
BE EXTREMELY CAREFUL CROSSING THE HIGHWAY!

24.4	4.1	Proceed west on Rt. 44-55. Turn out on right at hairpin curve.

STOP #8: Here Martinsburg strata, which appear to be Bushkill, may actully be Pen Argyl Equivalent though they do not resemble the latter. Here and at STOP #9, a short distance away, the strata occur in the open fold domain and in the immediate vicinity the overlying Shawangunk conglomerate may reflect Acadian or later deformation which was superposed on a predominantly Taconian structure.
Proceed 'west' on Rt. 44-55.

24.9	0.5	Turn left VERY CAREFULLY on BLIND CURVE into parking area at Lookout. Park if possible. It may be very crowded with climbers and tourists on good weather days.

STOP #9: Facing northwest we see the relative attitudes of the underlying Martinsburg (Pen Argyl Equivalent?) and the overlying Shawungunk conglomerate. Although the angular unconformity between the two can be projected, the actual contact can be seen just south of Rt. 44-55 at the base of the Shawungunk (Waines and Sanders, 1968). The study of the relative structure of the Shawangunk and Martinsburg in this immediate vicinity was conducted by Persico (1984). He concluded that some Taconic structures were further deformed at a later time.

Next, a view to the southeast and east stretches beyond the immediate Wallkill Valley to the Hudson Highlands and the Hudson River Gap (southeast) and the Housatonic Ridge along the Connecticut border to the east. Closer at hand, to the east, we can retrace our general progress of the day from the irregular ridge of the Marlboro Mountains (overturned east limb of the Marlboro Syncline). Slightly closer we drop in elevation across the east dipping monoclinal domain which cannot be recognized from this viewpoint. We know that the complex domain centers on the lower elevations of the Wallkill Valley, but again the domain cannot be recognized from here. Similarly, the open fold domain and its eastern boundary fault give no indication of their presence. It must be concluded that only extensive exposure data (borings, tunnels) are necessary to augment meager or fortuitous exposures as in Stops 6 and 7.

END OF TRIP.

Return to Kingston Ramada Inn by way of Rt. 44-55, NY 299 and NYS Thruway.