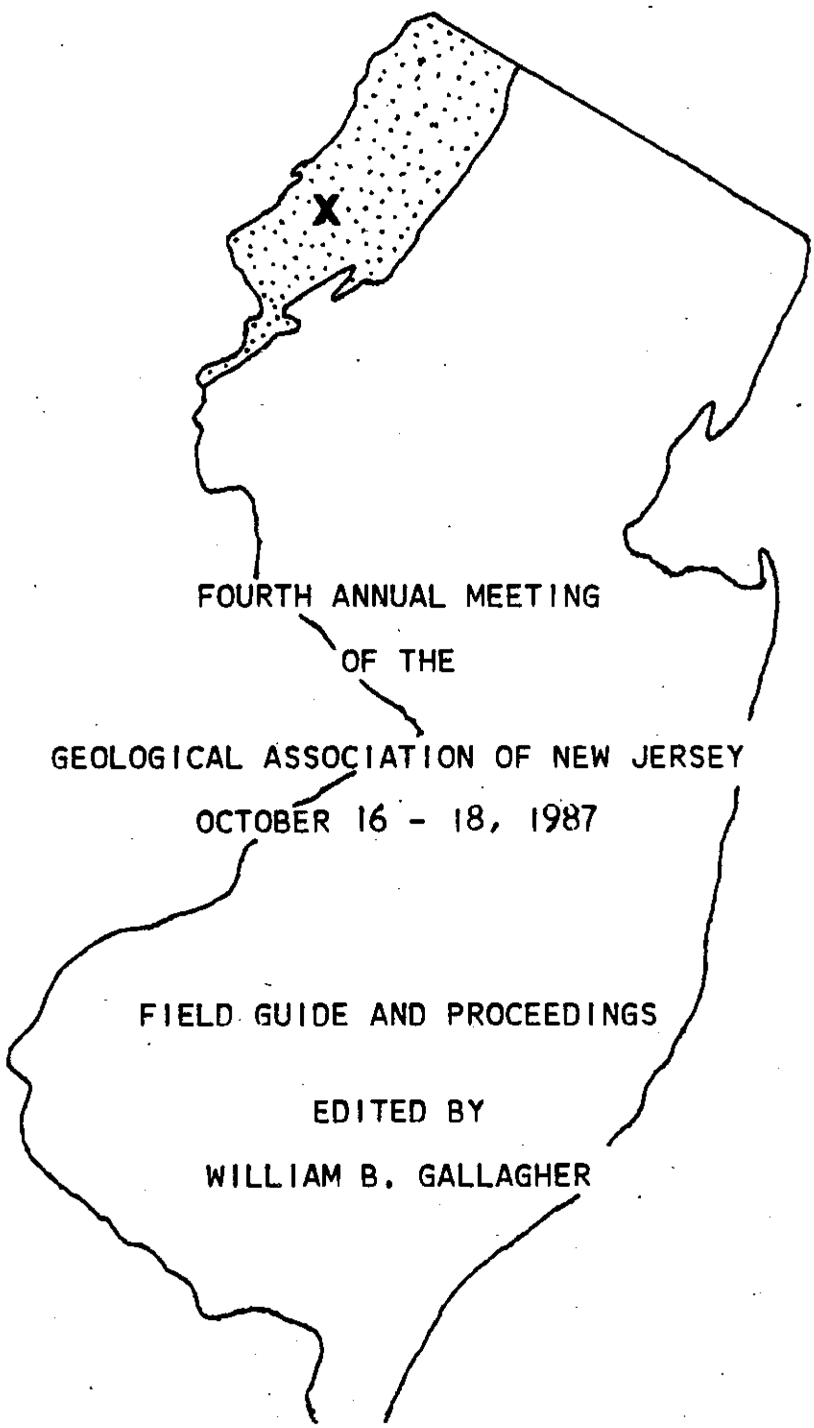
Paleontology and Stratigraphy of the Lower Paleozoic Deposits of the Delaware Water Gap Area



FOURTH ANNUAL MEETING

OF THE

GEOLOGICAL ASSOCIATION OF NEW JERSEY

OCTOBER 16 - 18, 1987

FIELD GUIDE AND PROCEEDINGS

EDITED BY

WILLIAM B. GALLAGHER

PALEONTOLOGY AND STRATIGRAPHY OF THE LOWER PALEOZOIC DEPOSITS OF THE DELAWARE WATER GAP AREA

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FOURTH ANNUAL MEETING OF THE
GEOLOGICAL ASSOCIATION OF NEW JERSEY
OCTOBER 16 - 18, 1987

HOSTED BY
THE SCIENCE BUREAU
NEW JERSEY
STATE MUSEUM AT
CAMP MASON,
BLAIRSTOWN, NJ

FIELD TRIPS LED BY
DAVID C. PARRIS,
SHIRLEY S. ALBRIGHT,
WILLIAM B. GALLAGHER

GEOLOGICAL ASSOCIATION OF NEW JERSEY
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SEQUENCE OF PAPERS

ROAD LOG
PALEONTOLOGICAL SITES ON THE ORDOVICIAN, SILURIAN, AND DEVONIAN SYSTEMS OF THE DELAWARE WATER GAP REGION

BY

David C. Parris, Shirley S. Albright, and William B. Gallagher
New Jersey State Museum
Science Bureau, CN-530
Trenton, NJ 08625

Welcome to the Delaware Water Gap and the Geological Association of New Jersey field conference! The New Jersey State Museum has performed field studies in this area since 1973 in close association with the National Park Service. We wish to acquaint you with some of the paleontological sites which have occupied our attention through the years. Some of them were discovered and published by Weller (1903), whose specimens are in the State Museum's classic early collections. Others were discovered within the last few years and are published for the first time here. Our research here is on-going, and we welcome your suggestions and criticisms.

As with all our field trips, we have included notes of the history and natural history of the route to add (we hope) to your appreciation of this region.

Mileage Interval	Mileage Total	
0.0	0.0	Depart Camp Mason, turn right at Camp entry.
.3	.3	Turn left on Millbrook-Blairstown Road
1.7	2.0	Turn left on County Route 659 (Spring Valley Road)
1.9	3.9	Turn left onto County Route 521 (Stillwater Road) You are traveling roughly along the trend of the Jacksonburg Limestone (Ordovician), the uppermost of the early Paleozoic carbonate formations. It contains a rich shelly fauna, described by Weller and other early workers as "Trenton" equivalent. Its topographic expression as well as its relation to the overlying Martinsburg Formation is of principal interest on this trip. Note the numerous lakes and sinkholes, typical of a karst landscape. The Jacksonburg Formation has a gradational contact with the Bushkill Member, lowest of the three Martinsburg members in this region. Various outcrops of the Jacksonburg Limestone are visible along this route, many of which are fossiliferous.
2.4	6.3	Entering Sussex County (Stillwater Township). The county was named by Governor Jonathan Belcher in honor of the Duke of Newcastle, whose family seat was in the English county of Sussex. The township was named for the village, which in turn was named by early resident Casper Shafer, presumably because of the agreeable condition of local streams and lakes.
1.1	7.4	Entering Village of Stillwater. Turn left and stay on County Route 521. When Route 521 abruptly turns right, go straight. Do <u>not</u> turn with Route 521. Park just ahead on the right.
1.7	9.1	STOP 1: <u>VILLAGE OF MIDDLEVILLE (MIDDLEVILLE INN)</u>

Our first stop is within the basal 50 meters of the Martinsburg Formation. This lowest stratigraphic unit of the Martinsburg is called the Bushkill Member. It is overlain (though not at this site) by the Pen Argyl and Ramseyburg Members. By coincidence, the most convenient route to our four stops will present them in sequence beginning with the lowest and earliest.

Mileage Interval	Mileage Total	

Fauna of the Bushkill Member at
Middleville, Stillwater Township,
Sussex County, New Jersey
(OM-22 of NJSM records)

Graptolites:	<u>Glyptograptus</u> <u>euglyphus</u> Lapworth
Brachiopods:	<u>Plectorthis</u> sp.
	Genus Indeterminate
Gastropods:	<u>Murchisonia</u> sp.
	Genus Indeterminate
Pelecypods:	<u>Prolobella</u> <u>trentonensis</u> (Conrad)
	Genus Indeterminate
Cephalopods:	Nautiloidea
Echinoderms:	Crinoidea
Other:	cf. <u>Cornulites</u> sp.

To our knowledge, this fauna has not previously been published. We first collected graptolites here in 1984 and have subsequently recovered shelly fauna (Parris et al., this volume). The abundant graptolites are pyritized and appear white against the dark shale. The slaty cleavage is at a relatively low angle to the bedding and the graptolites are thus rather easy to collect. You are welcome to collect as much as you wish. All the graptolites are probably <u>Glyptograptus</u> <u>euglyphus</u> Lapworth. The shelly fauna including gastropods (<u>Murchisonia</u>), pelecypods (<u>Prolobella</u>), nautiloids, and brachiopods (<u>Plectorthis</u>), is of prime research interest to us, so we ask that any specimens of shelly fauna be donated to the State Museum. (The finder will be given credit as a donor.) The chance to find datable shelly and graptolite faunas in one outcrop rarely comes to us, so we must take full advantage of this opportunity. Turn around, head south on County Route 521. (Retrace route)

1.7	10.8	Stillwater Village. Turn right and continue on County Route 521.
1.1	11.9	Re-enter Warren County (Hardwick Township). The county was named for a Massachusetts physician, Joseph Warren, who was killed at the Battle of Bunker Hill. Hardwick, one of the original townships of what are now Sussex and Warren Counties, was formed by royal patent about 1713. The origin of the name is uncertain.

Mileage Interval	Mileage Total	
2.4	14.3	Intersect County Route 659. Continue ahead on County Route 521. Entering Blairstown Township, named for John I. Blair, a prominent citizen of the nineteenth century.
2.3	16.6	In Blairstown, turn left at first intersection, then immediately right onto State Route 94. Blairstown is noted for its quaintly historic Main Street, as well as the Blair Academy, a notable private school.
2.3	18.9	Escarpment of Shawangunk Conglomerate on right horizon. The Shawangunk Conglomerate is the first major ridge-forming formation on the southeast flank of the Valley and Ridge physiographic province. The Appalachian Trail follows its crest through New Jersey.
1.3	20.2	Turn right onto Walnut Valley Road at the intersection with the Dairy Queen (unofficially known as NJSM Outcrop # DQ-2).
2.4	22.6	Arrive at Yard's Creek Guard Station. Request permission to visit the site.
.2	22.8	Stop 2A: YARD'S CREEK PUMPED STORAGE STATION VISITOR CENTER.

A brief visit to the exhibition area is scheduled. The geological engineering that made this project possible has been published in detail (Smith, 1969). Restrooms are available.

.8 23.6 STOP 2B: PICNIC AREA.

The Martinsburg Formation (Ramseyburg Member) is exposed at the picnic area and penstock. We have scheduled two hours for inspection of Stops 2B and 2C. The participants are to be divided into three groups. Please observe your schedules strictly! One group will ascend penstock to State Museum Locality Om-30 and the Martinsburg-Shawangunk contact. A leader will accompany you. Those who are not back in the parking area in one hour could miss the next area, the upper reservoir visit.

Mileage Interval	Mileage Total	

Buses will turn left out of parking area; ascend on road to upper reservoir. (Because of limited turn-around space, it may be necessary to take buses one or two at a time.)

1.2 24.8 STOP 2C: <u>UPPER RESERVOIR MARGINS</u>
The bedrock and most of the boulder-sized rubble is the Upper Member of the Shawangunk Formation. The metaconglomerate is familiar to virtually everyone, especially Appalachian trail hikers. Not so familiar are the argillite beds that can be seen easily in the construction rubble. Many fragments of pyritized eurypterids are found in these argillite layers, and you may keep anything you find. Please observe all rules and regulations of the Yard's Creek Pumped Storage Station. We are guests of this facility and the privilege of entering the chain gate and driving to the upper reservoir is rarely given!

1.2	26.0	Return to the picnic area for lunch (one hour).
.8	26.8	Return to the guard station. Wave thanks to guard! Retrace route on Walnut Valley Road.
1.6	28.4	Turn right onto State Route 94.
1.8	30.2	Enter Knowlton Township, supposedly named for the knolls and hills that characterize the terrain.
.8	31.0	Enter village of Hainesburg. Note quaint hotel on left. Just south and west of Hainesburg (off Hainesburg River Road) is the site of the Babcock property where a remarkable specimen of <u>Cervalces scotti</u> Lydekker was found. Now housed at the Natural Science Museum in Paulina (Blairstown Township), this specimen (NSM 264) is only the second-known nearly complete skeleton of a Pleistocene elk-moose. The other definitive specimen (PU 10648) was found a few kilometers to the east, near Mount Hermon, New Jersey. It is in the Princeton University Natural History Museum.
2.2	33.2	Roadcuts on the left expose the Allentown Dolomite (Cambrian-Ordovician). Follow signs to Interstate 80 Westbound.

Mileage Interval	Mileage Total	
1.6	34.8	From I-80, the Delaware Water Gap is visible straight ahead with exposures of Shawangunk Formation.
1.1	35.9	Defunct Delaware Water Gap slate quarries are in woods on the right. They are not visible from the roadway. The slate industry flourished in this region through most of the nineteenth century. A few quarries remain active in Pennsylvania, mostly in the Bushkill and Pen Argyl Members of the Martinsburg Formation. There were few quarries in New Jersey of these "Hudson River Slates". The Delaware Water Gap quarries were in the Ramseyburg Member, not usually noted for its slates. Lack of convenient railway access was a problem for the Delaware Water Gap quarries, and they were never very competitive.
.7	36.6	Passing the Shawangunk and Martinsburg Formations in fault contact. During one construction period the contact was exposed. One specimen of _Triarthus beckii_ Green was found here (Beerbower, 1956). The specimen (Lafayette College S161-2) is now on loan to the New Jersey State Museum. (Casts are available for exchange).
.3	36.9	Dunfield Creek; ascent of Appalachian Trail. The Appalachian Trail follows the course of Dunfield Creek partway up the ascent out of the Water Gap; the creek tumbles over numerous falls developed on the Bloomsburg Formation. Exit to right and follow signs for Visitor Center.
.6	37.5	Visitor Center for Delaware Water Gap National Recreation Area. Enter Pahaquarry Township, named for the local Indian name Pahaqualong, the name of the mountain (now Kittatinny Mountain).
.2	37.7	Begin traveling north on Old Mine Road.
.2	37.9	Traffic light (3 minutes). WAIT! It _will_ eventually change. The narrow roadway ahead does not permit two vehicles to pass each other, and failure to heed this light can lead to serious consequences.

Mileage Interval	Mileage Total	
1	38.0	Tollgate for I-80 bridge is visible at left. Outcrops of Bloomsburg Formation at tollgate yield fragments of Silurian ostracoderm fish, but the noise level makes collecting almost intolerable.
.8	38.8	Pass Keramac Parking area.
.4	39.2	STOP 3: SILURIAN FISH LOCALITY.

Buses stop to discharge passengers for this outcrop. Buses will proceed ahead to Douglass Trailhead turn around (2.5 miles), return to Keramac (3.0 miles) Parking area, wait 20 minutes and return to this stop to pick up passengers (.5 miles). This outcrop is on National Park Service land and absolutely no collecting is allowed!! It is a vertebrate fossil locality and protected under the Antiquities Act.

The Bloomsburg Formation is well-exposed in this roadcut and contains vast numbers of fish fragments. The most spectacular specimens are dorsal and ventral plates of the ostracoderms *Vernonaspis* and *Americaspis*. This outcrop (NJSM Locality 107) is part of a current taphonomic study by New Jersey State Museum paleontologists. It is important that nothing be damaged in order to preserve the integrity of the research. Please do not hammer on the outcrop. We have proposed it for eventual use as a trailside exhibit. Additionally, the Bloomsburg Formation (formally called the High Falls Formation) has yielded microfauna in some localities (Giffin, 1979).

6.0	45.2	Bus mileage at pick-up point.
2.5	47.7	Worthington State Forest area, Douglas Trailhead. Continue north on Old Mine Road.
1.8	49.5	Enter Delaware Water Gap National Recreation Area. The impetus for the establishment of Delaware Water Gap National Recreation Area was the Tocks Island Dam proposal. Despite the cancellation of the dam project, the federal government has continued to acquire land along the Delaware River and additional recreational enhancements are planned.
1.6	50.8	Pass Pahaquarry Copper Mine. Parking area on left. Mine adits are in the Bloomsburg Formation on the right. (They are not visible from the road). These workings and the Old Mine Road itself were the

Mileage Interval	Mileage Total	
		subject of a charming legend which still occasionally circulates. According to the legend, the Dutch settlers and immigrants along the Delaware River were the originators of the mine workings and also created the road (supposedly one of the earliest in what was to become the United States.) This is now generally taken to be untrue, as noted by McTernan (1969). No archaeological evidence supports the story (Kraft, 1974). As speculated by Parris (1982), the origin of the tale may have resulted from confusion of the two Neversink (Navesink) Rivers and the assumption that green minerals necessarily contained copper. The few Dutch references to copper deposits along the Neversink River may well have resulted from superficial examination of the glauconite marls of Monmouth County. The known history of the Pahaquarry copper mines has been described in various publications, (Weiss and Weiss, 1963) and recently rewritten by Yolton for the National Park Service. Various outcrops of the Bloomsburg Formation are visible along the road.
1.3	52.1	Calno School on left. It no longer serves as a school since depopulation of Pahaquarry Township has left the town with few children. Pahaquarry Township is said to be New Jersey's most sparsely populated municipality (about one person per square mile).
2.5	54.6	Watergate Recreation facility so named because it actually had a water gate. This proved to be an unfortunate coincidence by 1974. The name is only now beginning to lose its notoriety.
.4	55.0	Junction at Millbrook, a recreated nineteenth century village. Turn left and ascend hill on Old Mine Road.
.3	56.3	Re-enter Sussex County (Walpack Township). Walpack or Wallpack (both spellings are used locally) was named for the local Indian word for an eddy or whirlpool. Walpack was one of the original townships of what are now Sussex and Warren Counties.

Mileage Interval	Mileage Total	
.3	56.6	Intersection at Donkey Corner Road.
.1	56.7	Fossiliferous Bloomsburg Formation on roadcut to the right.
.5	57.2	Cross Flat Brook bridge. Turn right onto Sussex County Route 615. We are leaving Old Mine Road which continues to the left. The Wallpack (Bushkill) Bend is just to the south, where Flat Brook enters the Delaware River. Route 615 generally follows the Flat Brook which flows in the valley of the rarely-exposed Poxono Island Shale.
.3	57.5	Cemented Pleistocene glacial till precariously hovers over road on left.
1.4	58.9	SHARP TURN! CAUTION!!!
.3	59.2	Outcrops in the vicinity of Milepost 4 are in the overturned Esopus Formation. The Esopus Formation (Esopus Grit) forms most of the crest of the Walpack Ridge (called Godfrey's Ridge in Pennsylvania). The most important studies of Weller (1903) were made along this ridge, and his collections include some of the most important Paleozoic specimens in the New Jersey State Museum's collections.
.9	60.1	Pass outcrops of Minisink and New Scotland Formations on left.
.2	60.3	Right turn onto dirt road.
.4	60.4	STOP 4: HANEY'S MILL AREA.

This is an important site for inspection of late Silurian-Early Devonian formations. The Poxono Island Shale is not exposed, but the Bossardville, Decker, Rondout, and Coeymans Formations can all be seen. This is state property and you may collect fossils as much as you wish. For faunal lists from the various formations refer to Albright, 1987 (this volume). Please do not collect anything from the impressive mudcrack exposures in the Bossardville Formation. Indiscriminate hammering would soon destroy this spectacular outcrop. Buses should turn around for return; the stop will be one hour. Return to County Route 615. Turn left (south).

Mileage Interval	Mileage Total	
1.4	61.8	Pleistocene conglomerate again on right in case you missed it the first time.
.3	62.1	Flat Brook bridge. Turn left and go over bridge. We are ascending the hill but descending the stratigraphic section. Flatbrookville, a modest rural village, was one of the sites of a nineteenth century lime kiln where the Rondout Formation (Water Lime) was burned for agricultural lime. The site of the kiln is still recognizable. State Museum geologists noted pileated woodpeckers nesting in this area during 1984 and 1985.
2.1	64.2	Millbrook Village. Turn left and ascend hill. Millbrook is one of the more popular attractions of the Delaware Water Gap National Recreational Area. Visitors are especially attracted to Millbrook Days, an early October observance.
1.1	65.3	Cross Appalachian Trail Head (north). Note that here the Appalachian Trail dips down off the Shawangunk Conglomerate into a wind gap underlain at this point by the Martinsburg Formation.
.1	65.4	Cross Appalachian Trail Head (south).
.3	65.7	Re-enter Hardwick Township.
.2	65.9	Pass State Museum Locality Om-10 (on right) a fossil site in the Ramseyburg Member of the Martinsburg Formation.
1.9	67.8	Turn left.
.3	68.1	Turn left into Camp Mason.

REFERENCES CITED

Albright, Shirley S.
1987 (This volume) Faunal Lists of New Jersey's Silurian and Devonian Formations within the Delaware Water Gap National Recreation Area.

Beerbower, James
1956 The Ordovician-Silurian Contact, Delaware Water Gap, New Jersey: Pennsylvania Academy of Sciences Proceedings, Vol. 30, p. 146-149.

Giffin, Emily
1979 Silurian Vertebrates from Pennsylvania: Journal of Paleontology:53: p. 438-445.

Kraft, Herbert
1974 Indian Prehistory of New Jersey, in Kraft, ed. A Delaware Indian Symposium: Commonwealth of Pennsylvania, Historical and Museum Commission, Anthropological Series, No. 4, 159 pages.

McTernan, D.
1969 The Esopus-Minisink Way: Manuscript on file at Delaware Water Gap National Recreation Area: Unpublished thesis.

Parris, David C.
1982 Historical Mineral Industries of the Delaware Water Gap Area: Unpublished contractual report to Delaware Water Gap National Recreation Area.

Parris, David C., Kenneth M. Cruikshank, and John L. Rich
1987 (This volume) New Biostratigraphic Information on the Ordovician of New Jersey and Adjacent Areas.

Shampanore, Frank
1929 History and Directory of Warren County, NJ, Washington, NJ: Shampanore and sons, 645 pages.

Smith, Bennett L.
1969 Engineering Geology of the Yards Creek Hydro-electric Pumped Storage Project: in Subitzky, S., Geology of Selected Areas in New Jersey and Eastern Pennsylvania: Rutgers University Press, p. 348-353.

Snell, James P.
1981 (Originally 1881) The History of Sussex and Warren Counties, New Jersey: Centennial edition. Harmony Press, Harmony, NJ, 470, pages.

Weiss, Henry B. and Grace M. Weiss
1963 The Old Copper Mines of New Jersey, The Past Times Press, Trenton, NJ, 94 pages.

Weller, Stuart B.
1903 The Paleozoic Faunas: New Jersey Geological Survey Report on Paleontology, Vol. 3, 462 pages.

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FAUNAL LISTS OF NEW JERSEY'S SILURIAN AND DEVONIAN FORMATIONS WITHIN THE DELAWARE WATER GAP NATIONAL RECREATION AREA

Compiled by Shirley S. Albright
New Jersey State Museum

The following faunal lists have been extracted from Weller's classic work of 1903, Beerbower's report on Silurian fish, and Babcock's revision of Devonian Conulariids. The fauna has been reorganized to reflect the stratigraphic range of reported genera and species and their assignment to higher taxa. In most cases, no attempt has been made to update the paleontological nomenclature. Weller's work has never been reprinted. It is extemely difficult to find, so this reference will assist those who are interested in identifying specimens from the area. It should be noted that the New Jersey State Museum is the repository for Weller's collections as well as for field collections by Museum staff since 1978. In reports to the National Park Service, Parris and Albright (1979, 1980) have listed the catalogue numbers associated with each listing. Approximately 70% of the genera and species listed on the following pages have voucher specimens in the Museum's collections.

In order to ease the process of making comparisons from one stratigraphic unit to another, each formation has been assigned a number. The code utilized on the following pages is as follows:

FORMATION CODE	FORMATION AND/OR MEMBER
1	Shawangunk Formation
2	Bloomsburg Formation (High Falls)
3	Bossardville Formation
4	Decker Formation (Decker Ferry)
5	Rondout Formation
6	Manlius Formation, Coeymans Formation (DePue Member)
7	Coeymans Formation (Peters Valley, Shawnee Island, Stormville Members), Kalkberg Formation
8	New Scotland Formation
9	Minisink Formation
10	Port Ewen Formation
11	Oriskany Formation
12	Esopus Formation
13	Schoharie Formation
14	Buttermilk Falls Formation (Onondaga)
15	Marcellus Formation

Megafossils have not been reported from the Poxono Island Formation, located stratigraphically between the Bloomsburg and Bossardville Formations. It should also be noted that microfossils and flora have not been included in this report.

DESCRIPTION	FORMATION CODE 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
PHYLUM PORIFERA															
Class Stromatoporoidea				x	x	x	x								
<u>Stromatoporella</u> <u>constellata</u>				x			x								
<u>S.</u> sp.					x										
Class Demospongea															
<u>Hindia</u> <u>fibrosa</u>								x							
PHYLUM BRYOZOA															
<u>Escharopora</u> <u>siluriana</u>				x											
<u>Ptilodictya</u> <u>frondosa</u>				x											
<u>P.</u> <u>lobata</u>							x								
<u>Lichenalia</u> sp.				x											
<u>L.</u> cf. <u>torta</u>					x		x								
<u>Monotrypa</u> <u>corrugata</u>				x											
<u>M.</u> <u>sphaerica</u>							x								
<u>Fenestella</u> sp.							x								
PHYLUM CNIDARIA (COELENTERATA)															
Class Scyphozoa															
Order Conulariida															
<u>Reticulaconularia</u> <u>sussexensis</u>												x			
Class Anthozoa				x	x		x	x	x		x	x	x	x	x
<u>Vermipora</u> sp.				x											
<u>V.</u> <u>serpuloides</u>											x				
<u>Diphyphyllum</u> <u>integumentum</u>				x											
<u>Hexagonaria</u> <u>inequalis</u>				x											
<u>Coenites</u> <u>rectilineata</u>				x											
<u>Favosites</u> sp.											x				
<u>F.</u> <u>pyriformis</u>				x											
<u>F.</u> <u>corrugatus</u>				x											
<u>F.</u> <u>helderbergiae</u>							x								
<u>F.</u> cf. <u>turbinatus</u>														x	
<u>Halysites</u> <u>catenularia</u>				x											
<u>Zaphrentis</u> sp.				x								x			
<u>Z.</u> cf. <u>roemeri</u>					x		x								
<u>Z.</u> <u>simplex</u>														x	
<u>Aulopora</u> cf. <u>tonolowayensis</u>					x										
<u>Chaetetes</u> cf. <u>abruptus</u>					x										
<u>Enterolasma</u> <u>strictum</u>					x		x	x	x						
<u>Cladopora</u> <u>multiseriata</u>							x								
<u>Trachypora</u> <u>oriskania</u>											x				
<u>Amplexus</u> sp.														x	
PHYLUM ANNELIDA															
Class Polychaeta															
<u>Spirorbis</u> sp.				x											

DESCRIPTION	FORMATION CODE														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
PHYLUM BRACHIOPODA															
Linqula sp.	x														
L. cf. *delia*															x
L. ligea															x
Craniops sp.										x					
C. ovata				x							x				
C. arenaria											x				
Stropheodonta sp.									x				x		
S. bipartita				x											
S. varistriata					x	x	x								
S. planulata							x								
S. beckei								x	x						
S. punctulifera								x							
S. magnifica										x	x				
S. perplana														x	
Orthothetes sp.											x				
O. deckerensis				x											
O. interstriatus				x											
O. woolworthana							x	x							
Leptaena rhomboidalis				x			x	x	x	x	x		x	x	
Chonetes jerseyensis				x											
C. cf. *aroostookensis*										x					
C. cf. *hemisphaericus*													x	x	
C. hudsonica										x	x				
C. arcuatus														x	
C. mucronatus															x
C. scitulus															x
C. setiger															x
Orthis flabellites				x											
Dalmanella postelegantula				x											
Cyrtina sp.							x							x	
C. magniplicata				x											
C. varia											x				
C. rostrata											x				
Rhipidomella preoblata				x											
R. oblata								x	x	x	x				
R. cf. *musculosa*											x				
R. eminens								x							
R. vanuxemi												x		x	
R. alsa														x	
Stenocisma deckerensis				x	x										
Rhynchonella sp.						x									
R. agglomerata				x											
R. semiplicata							x								
R. altiplicata							x								
R. transversa							x								
R. formosa								x							
R. breviplicata											x				
R. bialveata											x				

DESCRIPTION	FORMATION CODE 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
PHYLUM BRACHIOPODA (continued)															
Pentamerus circularis				x											
Atrypa reticularis				x			x							x	
cf. A. lamellata				x											
A. spinosa														x	
Camarotoechia litchfieldensis				x											
C. barrandei											x				
C. prolifica															x
cf. Wilsonia globosa				x											
Rhynchospira formosa				x			x								
Reticularia bicostata				x											
Spirifer sp.				x											
S. cyclopterus							x	x	x						
S. nearpassi									x						
S. octocostatus							x								
S. varicosus												x		x	
Howellella vanuxemi				x		x									
Whitfieldella nucleolata				x											
Hyattella cf. lemellosa					x										
Centronella biplicata						x									
cf. C. sp.										x					
cf. C. subrhomboidea								x							
Uncinulus mutabilis						x	x								
U. pyramidatus							x	x							
U. nucleolatus							x								
U. vellicatus								x	x						
Strophonella indenta							x								
S. punctulifera							x		x						
S. levenworthana								x							
Schizophoria bisinuata							x								
S. multistriata									x						
Gypidula coeymanensis							x								
G. angulata							x								
Rhynchotreta transversa							x								
Nucleospira concinna							x								
N. ventricosa							x	x							
Meristella laevis							x	x	x						
M. lata											x				
M. princeps											x				
M. cf. nasuta													x	x	
Pholidops ovata								x							
Glossina spatiosa								x							
Orthostrophia strophomenoides								x							
Isorthis perelegans								x		x	x				
Eospirifer macropleurus							x	x							
Levenea subcarinata								x							
Bilobites varica								x							
Scenidium insigne								x							
Eatonia medialis								x							
E. peculiaris											x				
E. singularis								x							

DESCRIPTION	FORMATION CODE 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
PHYLUM BRACHIOPODA (continued)															
Delthyris perlamellosus								x							
Atrypina imbricata								x							
Trematospira multistriata								x							
Anoplotheca concava								x						x	
A. flabellites											x				
A. dichotoma											x	x	x		
A. acutiplicata												x	x	x	
Rhychotrema formosum									x		x				
Schuchertella woolworthana										x					
S. pandora														x	
S. variabilis														x	
Chonostrophia cf. complanata										x	x				
C. jervensis											x				
Leptostrophia oriskania										x					
Schizocrania superincreta											x				
Orbiculoidea sp.														x	x
O. ampla											x				
O. jervensis											x				
Hipparionyx proximus											x				
Anoplia nucleata											x				
Beachia suessana											x				
Levenea subcarinata											x				
Rensselaeria subglobosa											x				
Costispirifer arenosus											x				
Acrospirifer murchisoni											x				
Metaplasia pyxidata											x				
M. plicata											x				
Leptocoelia cf. flabellites												x	x		
Eodevonia arcuatus												x			
Pentamerella sp.														x	
Synphoria stemmatus														x	
Elytha fimbriata														x	
Amphigenia elongata														x	
Strophalosia truncata															x
Liorhynchus limitare															x
L. laura															x
Tropidoleptus carinatus															x
Mucrospirifer mucronatus															x
Ambocoelia umbonata															x
A. nana															x

DESCRIPTION	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
PHYLUM MOLLUSCA															
Class Pelecypoda															
Edmondia deckerensis				x											
Pterinea sp.					x										
P. emacerata				x											
Nucula sp.				x											
Ptychopteria cf. _subquadrata_				x											
Mytilarca sp.								x							
M. obliqua				x											
Actinopteria sp.								x	x						
A. reticulata				x											
A. communis							x								
_A._ cf. _textilis_										x	x				
A. insignis											x				
A. muricata															x
Goniophora sp.				x							x				
Megambonia aviculoidea						x									
M. parva											x				
M. bellistriata											x				
Rhombopteria clathratus							x								
Conocardium sp.							x								
Cypricardinia sublamellosa								x							
Palaeoneilo sp.										x					
Nuculites triqueter															x
Panenka costata															x
Liopteria laevis															x
Lunulocardium curtum															x
Nyassa subalata															x
Aviculopecten invalidus															x
A. scabridus															x
Allocardium cf. _alternatum_															x
Modiomorpha alta															x
Class Gastropoda															
Straparollus sp.				x											
Platyceras sp.				x											
P. gibbosum							x								
P. tortuosum											x				
_P._ cf. _dumosum_												x			
P. undatum												x			
Loxonema sp.				x											
_L._ cf. _fitchi_						x									
L. attenuata								x							
L. jerseyensis											x				
Holopea antiqua						x									
Bulimorpha helderbergae							x								
Strophostylus gebhardi								x							
Platyostoma sp.													x		
P. ventricosa											x				
P. nearpassi											x				
P. desmatum											x				

DESCRIPTION	FORMATION CODE 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
PHYLUM MOLLUSCA (continued)															
Class Cephalopoda	x														
Family Michelinoceratidae				x		x		x			x	x	x	x	x
Michelinoceras sp.													x		
Rutoceras jason													x		
Agoniatites sp.													x	x	
Goldringia sp.														x	
Nephritoceras bucinnum															x
Bactrites cf. _clavus_															x
PHYLUM ARTHROPODA															
Class Merostomata															
Subclass Eurypterida	x														
Hughmilleria cf. _shawangunk_	x														
Class Ostracoda			x	x	x	x	x		x	x	x	x			
Family Leperditiidae			x												
Leperditia sp.											x				
L. altoides				x											
L. alta					x	x									
L. welleri					x										
L. elongata					x										
Bythocypris nearpassi				x											
Beyrichia sp.							x		x		x				
B. sussexensis				x											
B. barretti				x											
B. perinflata				x											
B. jerseyensis				x											
B. nearpassi				x											
B. deckerensis				x											
B. manliensis						x									
B. smocki						x									
B. kummeli						x									
B. montiguensis						x									
Kloedenia sp.					x										
Class Trilobita				x			x	x	x	x	x		x		
Calymene camerata				x											
Proetus pachydermatus				x											
P. protuberans							x								
cf. _P. depressus_				x											
cf. _P. spinosus_				x											
Dalmanites sp.										x					
D. aspinosa				x											
Odontochile micrurus							x	x	x	x					
Phacops sp.							x								
P. logani								x	x						
P. rana														x	
P. bufo														x	
P. cristata var. _pipo_														x	

DESCRIPTION	FORMATION CODE 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
PHYLUM ARTHROPODA (continued)															
Class Trilobita (continued)															
Trimerus vanuxemi									x		x				
T. dekayi														x	
Lichas pustulosus									x						
Synphoria whiteavesi										x					
Corycephalus dentatus											x				
Trypaulites cf. _erinus_														x	
Odontocephalus selenurus														x	
O. aegeria														x	
Phyllocarida sp.														x	
PHYLUM ECHINODERMATA															
Class Crinoidea				x	x		x	x	x	x	x	x			
Icthyocrinus magnaradialis								x							
Edriocrinus sacculus											x				
PHYLUM CHORDATA															
Class Agnatha															
Vernonaspis sp.		x													
Americaspis sp.		x													
UNCERTAIN AFFINITIES OR TRACE FOSSILS															
Burrows	x														
Coprolites	x														
Order Tentaculitida															
Styliolina fissurella															x
Tentaculites gyracanthus						x									
T. elongatus							x	x			x				
T. aculla											x				
Family Cornulitidae															
Cornulites cingulatus							x								
Order Hyolithida															
Hyolithes centennialis											x				
Taonurus caudagalli												x			

SELECTED BIBLIOGRAPHY

Babcock, Loren E. and Rodney M. Feldmann

1986 Devonian and Mississippian Conulariids of North America. Part A. General Description and Conularia: Annals of Carnegie Museum: 55: Article 15: p.349-410.

1986 Devonian and Mississippian Conulariids of North America. Part B. Paraconularia, Reticulaconularia, New Genus, and Organisms Rejected from Conulariida: Annals of Carnegie Museum: 55: Article 16: p.411-479.

Beerbower, J.R. and M.H. Hait, Jr.

1959 Silurian Fish in Northeastern Pennsylvania and Northern New Jersey: Pennsylvania Acad. Sci. Proc.: 33: p. 198-203.

Herpers Jr., H.F.

1949 A New Conularid from the Esopus Formation, Sussex County, New Jersey: New Jersey Dept. Conservation, Geological Survey Bull.: 60: 7 pp.

1950 Progress Report on a Study of the Esopus Formation in New Jersey, Southern New York, and Northeastern Pennsylvania: Unpublished manuscript, submitted to Lehigh University, Bethlehem, Pa.

1951 The Stratigraphy of the Rondout Limestone in New Jersey: New Jersey Dept. Conservation, Geol. Survey Bull.: 60: 14 pp.

Parris, David C. and Shirley S. Albright

1979 Fossil Resources of the Delaware Water Gap National Recreation Area. Part I: Silurian and Early Devonian Fossils: Unpublished contractual report to Delaware Water Gap National Recreation Area: 49 pp.

1980 Fossil Resources of the Delaware Water Gap National Recreation Area. Part II: Devonian Fossils: Unpublished contractual report to Delaware Water Gap National Recreation Area: 60 pp.

Thompson, Ida

1981 The Audubon Society Field Guide to North American Fossils: Alfred A. Knopf Publishers, New York: 846 pp.

Weller, Stuart B.

1903 The Paleozoic Faunas: New Jersey Geological Survey Report on Paleontology: 3: 462 pp.

NEW BIOSTRATIGRAPHIC INFORMATION ON THE ORDOVICIAN MARTINSBURG FORMATION OF NEW JERSEY AND ADJACENT AREAS

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ABSTRACT

Paleontological collections from Northern New Jersey, Eastern Pennsylvania, and Southern New York confirm that the Ordovician Martinsburg Formation can be sub-divided into three Members; the Bushkill, Ramseyburg and Pen Argyl Members. The Bushkill and Pen Argyl members are not equivalent in age as suggested by some previous workers.

The Bushkill Member consistently correlates from the *Climacograptus bicornis* to *Corynoides americanus* zones of Berry (latest portion of Riva's *Nemagraptus gracilis* to early *Diplograptus multidens* zones). The Ramseyburg Member correlates to the interval represented by the *Orthograptus ruedemanni* zone and the earliest part of the *Climacograptus spiniferus* zone of Berry (possibly equivalent to late *Diplograptus multidens* and early *Corynoides americanus* zones of Riva). The Pen Argyl Member correlates to the later part of the *Climacograptus spiniferus* zone of Berry (*Corynoides americanus* zone of Riva).

INTRODUCTION

A subject of much recent debate (e.g. Drake and Epstein, 1967; Wright *et al.*, 1979; Lash *et al.*, 1984) has been the subdivision of the Ordovician Martinsburg Formation in Eastern Pennsylvania into two or three members. The three-member division has been used by the U.S. Geological Survey in its mapping program, however, some workers feel that the upper member of the three-fold division is the lower member repeated by folding and faulting; thus a two-member subdivision would be more appropriate.

The objective of the present study was to obtain biostratigraphic control within the Martinsburg Formation in the Tri-State area (Pennsylvania, New Jersey and New York), and use these data to evaluate the three-member subdivision of the Martinsburg. Included in the study area are the type sections for all three members of the Martinsburg Formation (Drake and Epstein, 1967).

In this paper we present biostratigraphic information from the Martinsburg Formation in New Jersey (Warren and Sussex Counties), Pennsylvania (Northampton County), and New York (Orange County). Fossil localities within the study area have yielded fossils from all three stratigraphic units of the Martinsburg Formation. We also evaluate the graptolite data collected by Wright *et al.* (1979) in the area between Harrisburg and the Lehigh River in Pennsylvania.

Previous Studies

The Martinsburg Formation was first described by Geiger and Keith (1891), and named by Keith (1894) for exposures near Martinsburg, West Virginia (Drake and Epstein, 1967). The formation name is used for fine-grained clastic rocks (and their metamorphic equivalents) of Middle and Upper Ordovician age from New York to Tennessee. Use of the term Martinsburg Formation in New Jersey apparantly began with Lewis and Kummel (1918), for the pelitic rocks lying between the Middle Ordovician Jacksonburg Formation and the Ordovician/Silurian Shawangunk Formation.

Early biostratigraphic work in the Ordovician System of New Jersey was that of Stuart Weller (1903). Although Weller found little fossil material in the Martinsburg Formation, there was one notable exception, the Jutland area in Union and Clinton Townships, Hunterdon County. Here well-preserved graptolites were found in abundance.

The fauna of the Jutland region (currently referred to as the Jutland klippe) is fully discussed by Perissoratis *et al.* (1979), and by Parris and Cruikshank (1986). The youngest graptolites from the Jutland Klippe correlate to the *Nemagraptus gracilis* zone of Berry (1960, 1976) (Table I). The rocks of the Jutland area are apparently allochthonous, and represent an earlier phase of sedimentation prior to the deposition of the Martinsburg of the Slate belt (Lash and Drake, 1984; Lash *et al.*, 1984). The rocks of the Jutland klippe correlate with the Hamburg klippe in central Pennsylvania and should not be considered as part of the Martinsburg Formation as shown on the New Jersey State Geologic map (Lewis and Kummel, 1918).

Outside the Jutland area, Weller (1903) described two other Ordovician faunules from Sussex County in New Jersey. In Sussex Boro Weller (1903) reported a primarily shelly fauna, and a graptolite fauna was collected in Frankford Township (Weller, 1903, Locality 75B; Locality Om-31 in the Appendix). The material was sufficient to confirm Ordovician age but little else. The specimens reported by Weller from Frankford Township were reconsidered by Ruedemann (1949), but no detailed age conclusions resulted from the restudy.

Willard (1949) collected a shelly faunule in Stillwater Township, Sussex County which he attributed to the Eden Stage. The specimens have apparently been lost, but the exposure still exists, and has been reinvestigated as part of the present study (Locality Om-21, Appendix)

Beerbower (1956) cited an occurrence of *Triarthrus beckii* Green (Lafayette College S-161-2) from a fine grained sandstone of the Ramseyburg Member in a temporary exposure at the Delaware Water Gap. As the locality is no longer accessible, no further collecting was done, although implications of the find were reconsidered. This is the same species of trilobite that has been reported from Swatara Gap in Pennsylvania (Gerhart, 1983).

Berry (1971) described a graptolite fauna from the Martinsburg Formation in the Town of Greenville, Orange County, New York. The localities were apparently in the Ramseyburg (middle) Member (Locality Om-35, Appendix), and were ascribed to the *Climacograptus spiniferus* subzone of the *Orthograptus truncatus intermedius* zone (Berry, 1960, 1976).

Epstein and Berry (1973) collected a graptolite fauna at Lehigh Gap, Pennsylvania, in the Pen Argyl Member of the Martinsburg Formation from four localities. The fauna from each locality contained five to seven graptolite species, which correlated to the *Climacograptus spiniferus* subzone of the *Orthograptus truncatus intermedius* zone (Berry, 1970) (Table I).

Subdivision of the Martinsburg Formation

Within the study area the Martinsburg Formation is currently divided into three members (Fig. 1): a basal shale/slate unit, the Bushkill Member; a middle graywacke unit, the Ramseyburg Member; and an upper shale/slate unit, the Pen Argyl Member. A thorough description of these members, and a historical discussion of the stratigraphy, is given by Drake and Epstein (1967).

Although there are good stratigraphic, petrologic and structural arguments for a three-division Martinsburg Formation (e.g. Lash *et al.*, 1984), some workers (e.g. Wright *et al.*, 1979) feel that the Bushkill and Pen Argyl members are that same unit repeated by folding and thrusting.

The two member division has been favored by Lesley (1892), Lewis and Kummel (1918), Willard (1943), Wright and Stephens (1979), Wright *et al.* (1979), Stephens and Wright (1981) and Stephens *et al.* (1982). The most significant recent biostratigraphic work in eastern Pennsylvania is that of Wright *et al.* (1979).

The three member division has been used by Behre (1933), and by Drake and Epstein (1967). All geologic mapping by the U.S. Geological Survey since the work by Drake and Epstein (1967) has used the three member division. Because of the sparse fossil record, the three member division proposed by Drake and Epstein (1967) was the result of careful stratigraphic and structural mapping. Where the Ramseyburg member was seen in contact with the Pen Argyl member, the Pen Argyl member overlies the Ramseyburg. Where the Pen Argyl is overlain by the Ramseyburg member, it can be shown that the beds are locally overturned. Drake and Epstein (1967) had few biostratigraphic data.

Wright *et al.* (1979) based their two-member interpretation on fossil collections made in the area west of the Lehigh River and east of Harrisburg (Fig. 2). Biostratigraphic work was done to the south/west of Harrisburg, and is reported in Aldrich (1965) and Stephens and Wright (1981), but is not discussed here because the three-member subdivision of the Martinsburg Formation is only extended as far south/west as Harrisburg, Pennsylvania.

The faunal collections of Wright *et al.* (1979) correlated the Bushkill member with the *Diplograptus multidens* to *Orthograptus ruedemanni* zones of Riva (1969,1974). Sites in the Shochary Ridge, a sandstone unit (now designated the Shochary Sandstone and the New Tripoli Formation, by the U.S. Geological Survey; Lyttle *et al.*, 1986) correlated to the *Orthograptus ruedemanni* to *Climacograptus spiniferus* zones. The Shochary Ridge sandstone was regarded as being equivalent to the Ramseyburg member by Wright *et al.* (1979). Sites in what Wright *et al.* interpreted to be the Pen Argyl member, correlated to the

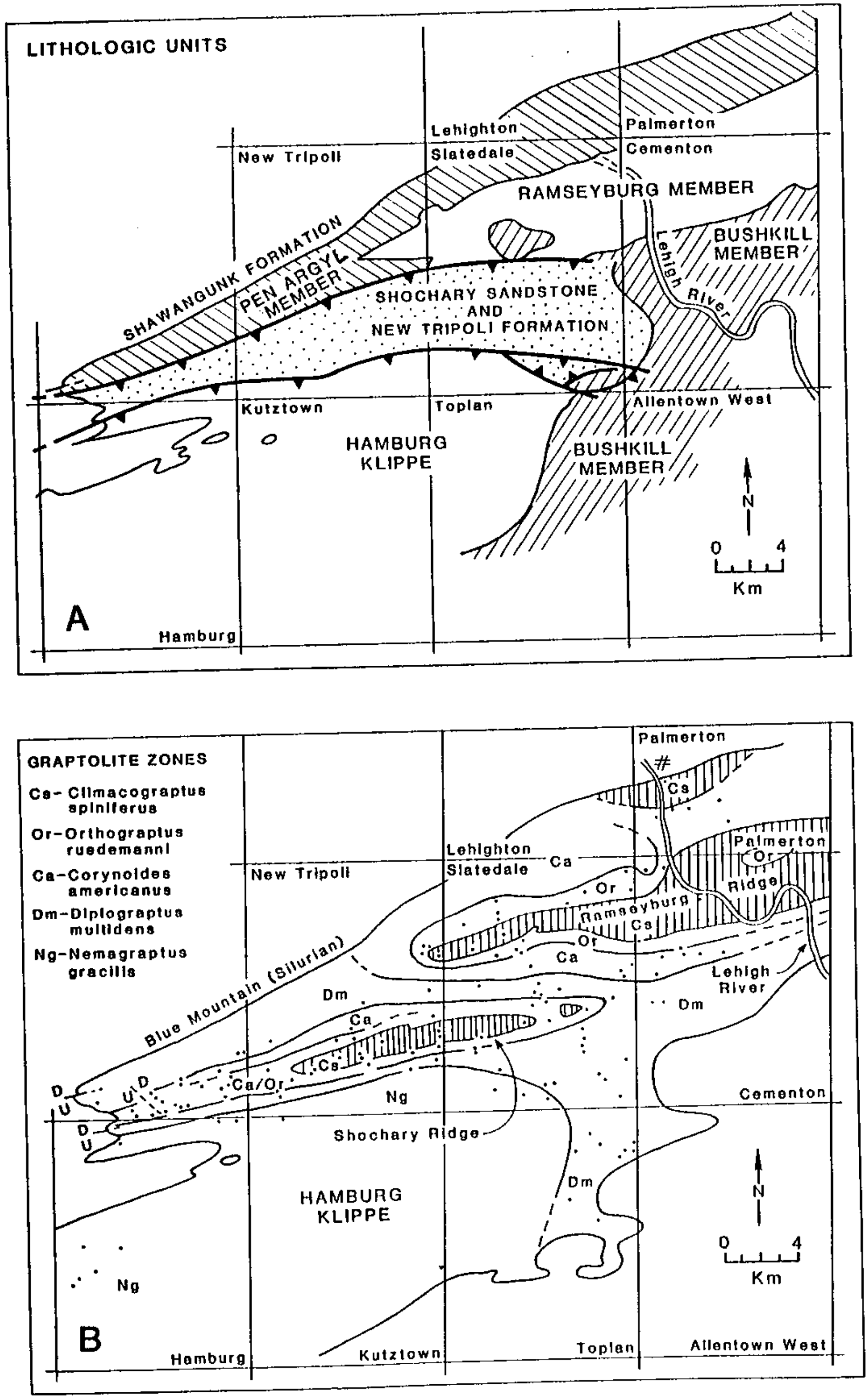

Figure 2. Distribution of (A) the stratigraphic units (from Lash and Drake, 1984; Lash et al., 1974; Lyttle et al., 1986), and (B) the biostratigraphy of Wright et al. (1979, Fig. 2)

Climacograptus spiniferus zone near the unconformable contact with the Ordovician/Silurian Shawangunk Formation, but with the *Orthograptus ruedemanni* zone near Shochary ridge.

Lash *et al.* (1984) cited work (e.g. Cisne and Chandlee, 1982) done in New England that suggests that graptolites may be susceptable to facies control, and argued that the reason the graptolite data of Wright *et al.* (1979) did not agree with the three-member division was that their correlations were unreliable because of facies control. One would expect, if facies control was important that there would be little regularity to the data collected by Wright *et al.* (1979); however their data do appear to be regular, even if their interpreted zone distributions do cross lithologic boundaries (Fig. 2).

Using the map of localities from Wright *et al.* (1979, Fig. 2), and the lithostratigraphy from the U.S.G.S. mapping program, (e.g. Lash 1982, 1984; Lyttle *et al.* 1986) the correlations given by Wright *et al.* (1979) agree well with those of this study. The only area where there still appears to be a problem is in the area on the East side of the Lehigh river where Wright *et al.* reported fossils of *Orthograptus ruedemanni* age from the Pen Argyl member. Their data cannot be evaluated here because site faunal lists are not given.

Shochary ridge has been interpreted to be a syncline (Wright *et al.*, 1979; Lyttle and Drake, 1979; Lyttle *et al.*, 1986), however Stephens and Wright (1978) and Wright *et al.* (1979) did not recognize that the Shochary ridge was bounded on the north and south by faults (Lyttle and Drake, 1979; Lyttle *et al.*, 1986) (Fig. 2b), and so interpreted the whole area to be a syncline to conform with a two-member subdivision and their fossil data. Wright *et al.* (1979) did not recognize that there are inliers of the Bushkill Member exposed on the North side of Shochary ridge (Fig. 2b). It appears that these inliers gave the Bushkill age graptolites in what Wright *et al.* interpreted to be the Pen Argyl member.

Although the interpretation of the graptolite distributions given by Wright *et al.* (1979) may be incorrect, their data base is excellent, and based on the structural interpretation of the area by Lyttle *et al.* (1986), the biostratigraphic data agrees with a three-member division of the Martinsburg formation, with the exception of the area to the East of the Lehigh River (Fig. 2).

NEW BIOSTRATIGRAPHIC DATA

Assignment of Graptolite Zones

Currently there is no universally accepted graptolite zonation for eastern North America. Two zonations are in common use (Table I), that of Berry (1960, 1976) and Riva (1969, 1974). These two schemes differ somewhat in theoretical approach and the preference of one over the other in some cases is equivalent to choice of structural and stratigraphic interpretation of the Ordovician System in the eastern region. The theoretical differences and debated points are well-summarized by Finney (1982) and will not be repeated here.

Where possible we will give our correlations for a locality according to both zonations, following the published correlation chart of Ross and Bergstrom (1982) (Table I).

TABLE I. Graptolite zonation for North America (after Sweet and Bergström, 1982).

<table>
<tr><th colspan="2">LITHOSTRATIGRAPHY</th><th colspan="3">BIOSTRATIGRAPHY</th></tr>
<tr><th colspan="2"></th><th colspan="2">Berry (1962, 1970, 1971)</th><th>Riva (1972, 1974)</th></tr>
<tr><td colspan="2" rowspan="2"></td><td rowspan="2">Orthograptus quadrimucanatus</td><td>Climacograptus manitoulinesis</td><td>Climacograptus spiniferus</td></tr>
<tr><td>Climacograptus pygmaeus</td><td>Orthograptus reudemanni</td></tr>
<tr><td rowspan="4">Martinsburg Formation</td><td>Pen Argyl member</td><td rowspan="3">Orthograptus truncatus intermedius</td><td>Climacograptus spiniferus</td><td>Corynoides americanus</td></tr>
<tr><td>Ramseyburg member</td><td>Orthograptus ruedemanni</td><td rowspan="2">Diplograptus multidens</td></tr>
<tr><td rowspan="2">Bushkill member</td><td>Corynoides americanus</td></tr>
<tr><td colspan="2">Climacograptus bicornis</td><td rowspan="2">Nemagraptus gracilis</td></tr>
<tr><td colspan="2"></td><td colspan="2">Nemagraptus gracilis</td></tr>
</table>

<u>Collection Methods</u>

The Martinsburg Formation from Plainfield Township, Northampton County, Pennsylvania to Greenville, Orange County, New York was prospected for fossils. Generally all roadcut, streamcut, and excavated exposures in New Jersey and selected exposures in Pennsylvania and New York were examined. In the event that any promising material was found, a bulk sample was taken and searched more diligently under the binocular microscope in the laboratory. Bulk samples of 100 kg were found to yield significant materials when thus processed, even when the field-examined materials had yielded little or nothing.

Collection of material within the study area was made difficult by the well developed slaty cleavage, and the high degree of metamorphism. There is essentially no metamorphism at Harrisburg, Pennsylvania, the grade has increases to Greenschist facies at the Pennsylvania-New Jersey boarder (Delaware River), and reaches Biotite grade at the Hudson River in New York. (Drake 1970, p. 277).

Many of the specimens recovered were preserved as thin pyrite films, thus they weathered easily and were rarely seen exposed on fresh surfaces. However, one could prospect outcrops for graptolites by looking for beds that appeared to have a higher pyrite content. These beds were sometimes stained and weathered differently from the rest of the outcrop.

Shelly invertebrate fossils were identified in the New Jersey State Museum faunal laboratory, and the graptolites were identified by Stanley Finney (Oklahoma State University) and Claire Carter (U.S. Geological Survey).

Overview of Biostratigraphic Data

Our collection from the Martinsburg indicates that the entire Martinsburg sequence fits within four graptolite zones, *Diplograptus multidens*, *Corynoides americanus*, *Orthograptus ruedemanni*, and *Climacograptus spiniferus* as described by Riva (1969; 1974). This is equivalent to the *Climacograptus bicornis* and *Orthograptus truncatus* var *intermedius* zones of Berry (1960, 1970) (Table I). This is the same age range as determined by Wright *et al.* (1979).

A composite faunal list for each member of the Martinsburg Formation is given in Table I. Table II gives correlations for different localities. Complete faunal lists and discussions of the correlations are given in the appendix.

DISCUSSION

Structural complexity and discontinuity of outcrops are major obstacles to stratigraphic work in this region. However, although we can rarely refer our sites to positions on measured sections, we can see consistency in the correlations of the three members of the Martinsburg Formation (Table II) within the study area.

The Bushkill Member consistently correlates from the *Climacograptus bicornis* to *Corynoides americanus* zones of Berry; this is equivalent to the later portion of the *Nemagraptus gracilis* and the early *Diplograptus multidens* zones of Riva.

TABLE II. Composite faunal list for each member in the study area. Complete faunal lists for each locality are in the Appendix.

BUSHKILL MEMBER	RAMSEYBURG MEMBER	PEN ARGYL MEMBER
GRAPTOLITE FAUNA		
Diplograptus folliaceus	*Climacograptus spiniferus*	*Climacograptus spiniferus*
D. angustifolius	*C. typicalis*	*Orthograptus* sp.
D. cf. *multidens*	*Dicranograptus ramosus*	
Dicellograptus smithi	*Orthograptus quadrimucronatus*	
Glyptograptus euglyphus	*O. calcaratus*	
Corynoides calicularis	*O. quadrimucronatus* var *approximatus*	
Climacograptus sp.	cf. *O. amplexicaulis*, *O. calcaratus*	
Glyptograptus sp.		
Lasiograptus mucronatus		
Orthograptus sp.		
SHELLY FAUNA		
Cryptolithus tessellatus	*Cryptolithus bellulus*	
Dalmanella testudinaria	*C. lorettensis*	
Plectorthis sp.	*Dinorthis*	
Murchinsonia sp.	*Sowerbella rugosa*	
cf. *Cornulites*	*Resseirella multisecta*	
	Promopaleaster	
	Cornulites sp.	

TABLE III. Summary of Graptolite correlations (Using Berry, 1960,1976) for localities where there was sufficient material available for correlation to a zone. Faunal lists for each locality are given in the Appendix.

Locality	Member	Graptolite Zone
Om-27	Pen Argyl	*Climacograptus spiniferus*
Om-5	Ramseyburg	*Orthograptus ruedemanni*
Om-10	Ramseyburg	*Climacograptus spiniferus*
Om-21	Ramseyburg	*Climacograptus spiniferus*
Om-30	Ramseyburg	*Orthograptus ruedemanni*
Om-35	Ramseyburg	*Climacograptus spiniferus*
Om-40	Ramseyburg	*Orthograptus ruedemanni*
Om-1	Bushkill	*Corynoides americanus*
Om-6	Bushkill	*Climacograptus bicornis*
Om-20	Bushkill	*Climacograptus bicornis*
Om-22	Bushkill	*Climacograptus bicornis*

The Ramseyburg Member correlates to the interval of the *Orthograptus ruedemanni* to the earliest part of the *Climacograptus spiniferus* zones of Berry, this is equivalent to the late *Diplograptus multidens* and early *Corynoides americanus* zone of Riva.

The Pen Argyl Member correlates to the later part of the *Climacograptus spiniferus* zone of Berry (*Corynoides americanus* zone of Riva).

Although we do not have sufficient resolution to indicate that the Pen Argyl is significantly younger than the Ramseyburg member, we have been able to demonstrate that it is younger than the Bushkill member. Thus, the Bushkill and Pen Argyl Members are of different ages and are not equivalent units.

When the inconsistencies between the lithologies Wright *et al.* (1979) cited to the north of the Shochary ridge and those mapped by Lyttle *et al.* (1986) are taken into account, the data from Wright. *et al.* agrees with the data that we have collected, with the exception of some sites in the Pen Argyl member east of the Lehigh River (Fig. 2).

Wright *et al.* (1977) report an extensive shelly and graptolite fauna from the Martinsburg Formation at Swatara Gap, in Central Pennsylvania. The outcrop correlates to the lower *Climacograptus spiniferus* zone of Riva (1974). The lithology of this locality, and its faunal composition suggests that this is equivalent to the Ramseyburg member of Eastern Pennsylvania.

Our age determination for the Pen Argyl member agrees with that determined for a fauna collected at Lehigh Gap, Pennsylvania (Epstein and Berry, 1973). The fauna at Lehigh Gap is more extensive than the fauna collected at Pen Argyl, and was determined to correlate with the upper *Climacograptus spiniferus* subzone of the *Orthograptus truncatus intermedius* zone of Berry (1960).

Further collecting, using our methods of bulk sampling and miscroscipic examinations should yield even more potential faunal localities. We intend to pursue this search for fossils in the area, but encourage others to do so.

CONCLUSIONS

The purpose of this study was to collect sufficient biostratigraphic data to be able to evaluate the three-member division of the Martinsburg formation currently used by the U.S. Geological Survey (Drake and Epstein, 1967). From our data we conclude that the three-member division is a valid division of the Martinsburg Formation.

Our data show that that both the Pen Argyl (later *Climacograptus spiniferus* zone) and the Ramseyburg member (*Orthograptus ruedemanni* to early *Climacograptus spiniferus* zone) are younger than the Bushkill (*Climacograptus bicornis* to *Diplograptus multidens* zone) member (Table I). Our data are insufficient at the current time to be able to place a upper limit on the age of the Pen Argyl member

The results from our investigation agree well with previously published material by Epstein and Berry (1973) and Wright *et al.* (1977). Our data agree with those of Wright *et al.* (1979) if we use the structural interpretation presented by Lyttle *et al.* (1986) for the area studied by Wright *et al.* (1979).

BIBLIOGRAPHY

Aldrich, M.J. 1965. Graptolites in a Martinsburg bentonite bed near Carlisle, Pennsylvania: *Pennsylvania Academy of Sciences Proceedings*, Vol. 39, p. 328-330.

Behre, Jr., C.H., 1933. *Slate in Pennsylvania*. Pennsylvania Geological Survey, Fourth Series, Bulletin M 16.

Beerbower, J. 1956. The Ordovician-Silurian contact, Delaware Water Gap, New Jersey: *Pennsylvania Academy of Sciences Proceedings*, Vol. 30, p. 146-149.

Berg, T.M., M.K. McInerney, J.H. Way, and D.B. MacLachlan. 1983. *Stratigraphic correlation chart of Pennsylvania*: Pennsylvania Geologic Survey, Fourth Series, General Geology Report 75.

Bergström, S.M., A.G. Epstein, and J.B. Epstein. 1972. Early Ordovician North Atlantic province conodonts in eastern Pennsylvania: United States Geological Survey Professional Paper 800-D, p. D37-D44.

Berry, W.B.N. 1960. *Graptolite faunas of the Marathon region, west Texas*: University of Texas Publication 6005. 179 p.

Berry, W.B.N. 1968. Ordovician paleogeography of New England and adjacent areas based on graptolites: *in*: Zen, E-An, W.S. White, J.B. Hadley, and J.B. Thompson, Jr., eds., *Studies of Appalachian geology: Northern Maritime*. Wiley Interscience, New York, p. 23-35.

Berry, W.B.N. 1970. Review of late middle Ordovician graptolites in eastern New York and Pennsylvania: *American Journal of Science*, Vol. 269, p. 304-313.

Berry, W.B.N. 1971. Late Ordovician Graptolites from Southeastern New York: *Journal of Paleontology*, Vol. 45, p. 633-640.

Berry, W.B.N. 1976. Aspects of correlation of North American shelly and graptolite faunas: *in*: Bassett, M.G., ed., *The Ordovician System*: Proceedings of a paleontological association symposium, Birmingham, September 1974: University of Wales Press and National Museum of Wales, Cardiff. p. 153-169.

Bullman, O.M.B. 1970. Graptolithina, with sections on Enteropneusta and Pterobranchia: *in* Teichert, C., ed., *Treatise on Invertebrate Paleontology*, Part V (2nd edition): Geological Society of American and the University of Kansas. 163 p.

Cisne, J.L., and G. Chandlee. 1982. Taconic foreland basin graptolites: age zonaiton, depth zonation, and use in ecostratigraphic correlation: *Lethaia*, Vol. 15, p. 343-362.

Drake, Jr., A.A. 1970. Structural geology of the Reading Prong: *in*: Fisher, G.W., and others, *Studies in Appalachian Geology: Central and Southern*. Wiley Interscience, New York. p. 271-291.

Drake, Jr., A.A. 1978. *The Lyon Station-Paulins Kill nappe -- The frontal structure of the Musconetcong nappe system in eastern Pennysivania and New Jersey*: United States Geological Survey Professional Paper 1023. 20p.

Drake, Jr., A.A., and J.B. Epstein. 1967. *The Martinsburg Formation (Middle and Upper Ordovician) in the Delaware Valley, Pennsylvania - New Jersey*: United States Geological Survey Bulletin 1244-H. 16 p.

Drake, Jr., A.A., J.B. Epstein and J.M. Arron. 1969. *Geologic map and sections of parts of the Portland and Belvidere Quadrangles, New Jersey - Pennsylvania*: United States Miscellaneous Geological Investigation Map I-552.

Drake, Jr., A.A., R.L. Kastelic, Jr., and P.T. Lyttle. 1985. *Geologic Map of the Eastern Parts of the Belvidere and Portland Quadrangles*: United States Geological Survey Map I-1530.

Drake, Jr., A.A., and P.T. Lyttle. 1985. *Geologic Map of the Blairstown Quadrangle, Warren County, New Jersey*: United States Geological Survey Map GQ-1585.

Drake, Jr., A.A., P. Lyttle, and J. Owens. 1978. *Preliminary geologic map of the Newark quadrangle, New Jersey - Pennsylvania*: United States Geological Survey Open File Report OF-78-595.

Epstein, J.B. 1969. *Surficial geology of the Stroudsburg quadrangle, Pennsylvania - New Jersey*: Pennsylvania Geological Survey, Fourth Series, General Geology Report 57, 67 p.

Epstein, J.B. 1970. *Geology of the Stroudsburg quadrangle and adjacent areas: Pennsylvania - New Jersey*: Unpublished dissertation, The Ohio State University. 339 p.

Epstein, J.B. 1973. *Geologic map of the Stroudsburg quadrangle, Pennsylvania - New Jersey*: United States Geological Survey Quadrangle Map GQ-1047.

Epstein, J.B. 1974. *Map showing slate quarries and dumps in the Stroudsburg quadrangle, Pennsylvania - New Jersey*, with a discussion of their environmental significance: United States Geological Survey Miscellaneous Field Studies Map MF-578A.

Epstein, J.B. and W.B.N. Berry, 1973. Graptolites from the Martinsburg Formation, Lehigh Gap, Eastern Pennsylvania. *Journal of Research*, U.S. Geological Survey, Vol. 1, No. 1, p. 33-37.

Epstein, J.B., and A.G. Epstein. 1967. Geology in the region of the Delaware to Lehigh Water Gaps: Guidebook for the *32nd Annual Field Conference of Pennsylvania Geologists*, distributed by the Pennsylvania Geological Survey, Harrisburg, Pennsylvania. 89 p.

Epstein, J.B., and A.G. Epstein. 1969. Geology of the Valley and Ridge province between Delaware Water Gap and Lehigh Gap, Pennsylvania: *in*, Subitzky, S., ed., *Geology of selected areas in New Jersey and eastern Pennsylvania, and guidebook of excursions*: Rutgers University Press, New Brunswick, NJ., p. 132-205.

Epstein, J.B., A.G. Epstein, and S.M. Bergström, 1972. *Significance of lower Ordovician Exotic Blocks in the Hamburg Klippe, Eastern Pennsylvania*. United States Geological Survey Professional Paper 800-D, p. D29-D36.

Epstein, J.B., W.D. Sevon, and J.D. Glaeser, 1974. *Geology and mineral resources of the Lehighton and Palmerton Quadrangles, Carbon and Northampton Counties, Pennsylvania.* Pennsylvania Geological Survey, 4th Series, Atlas 195cd. 460 p.

Finney, S.C. 1982. Ordovician graptolite zonation: *in*: Ross, Jr., R.J., and S.M. Bergström, eds., *The Ordovician system of the United States: Correlation chart and explanatory notes*: International Subcommission on Ordovician Stratigraphy, Publication No. 12. p. 14-23.

Finney, S.C. 1984. Biogeography of Ordovician graptolites in the southern Appalachians: *in*: Bruton, D.L., ed., *Aspects of the Ordovician System*: Paleontological Contributions from the University of Oslo, No. 295. Universitetsforlaget, p. 167-176.

Geiger, H.R. and A. Keith. 1891. *Bulletin of the Geological Society of America*: Vol. 2: p. 156-163.

Gerhart, J. 1983. Trilobites highlight a collection of fossils from Swatara Gap: *Pennyslvania Geology*, Vol. 14, No. 4, p. 2-8.

Jackson, D.E. 1969. Ordovician graptolite faunas in lands bordering North Atlantic and Arctic oceans: *in*: Kay, M., ed., *North Atlantic geology and continental drift*: American Association of Petroleum Geologists Memoir 12, p. 504-512.

Keith, A., 1894. *Harpers Ferry, Virginia-West Virginia-Maryland*: United States Geological Survey Atlas, Folio 10

Lash, G.G., 1982. *The geology of the Kutztown and Hamburg 7.5' quadrangles, eastern Pennsylvania.* U.S. Geological Survey Open-File Report 82-493.

Lash, G.G., 1985. *Geologic map of the Kutztown Quadrangle, Berks and Lehigh Counties, Pennsylvania.* U.S. Geological Survey Map GQ-1577.

Lash, G.G., and A.A. Drake, Jr. 1984. *The Richmond and Greenwich slices of the Hamburg klippe in eastern Pennsylvania - Stratigraphy, Sedimentology, Structure, and plate tectonic implications:* United States Geological Survey Professional Paper 1312. 40 p.

Lash, G.G., P.T. Lyttle, and J.B. Epstein. 1984. Geology of an accreted terrane: The eastern Hamburg klippe and surrounding rocks, eastern Pennsylvania: Guidebook for the *49th Annual Field Conference of Pennsylvania Geologists,* distributed by the Pennsylvania Geological Survey, Harrisburg, Pennsylvania. 151 p.

Lesley, J.P., 1892. *A Summary Description of the Geology of Pennsylvania*: Pennsylvania Geological Survey, 2nd Final Report. 3 Volumes.

Lesperance, P.J. and R. Bertand. 1976. Population systematics of the Middle and Upper Ordovician trilobite *Cryptolithus* from the St. Laurence lowlands and adjacent areas of Quebec: *Journal of Paleontology,* Vol. 50, no. 4, p. 598-613.

Lewis, J.V. and H.B. Kummel. 1918. *Geologic Map of New Jersey*: New Jersey Department of Conservation and Development, Atlas Sheet 40.

Lyttle, P.T., and A.A. Drake, Jr., 1979. Discussion of Regional implications of the stratigraphy and structure of Shochary Ridge, Berks and Lehigh Counties, Pennsylvania. *American Journal of Science*.

Lyttle, P.T., G.G. Lash, and J.B. Epstein, 1986. *Geologic map of the Slatedale Quadrangle, Lehigh and Carbon Counties, Pennsylvania*. U.S. Geological Survey Map GQ-1598.

Parris, D.C and K.M. Cruikshank. 1986. Ordovician Graptolites from a new locality near Jutland, New Jersey: *The Mosasaur*, Vol. 3.

Perissoratis, C., P. Brock, H. Brueckner, A.A. Drake, and W.B.N. Berry. 1979. The Taconides of western New Jersey: Evidence from the Jutland klippe: *Geological Society of America Bulletin*, Vol. 90, Part I, p. 10-13, and Part II, p. 154-177.

Platt, L.B., R.B. Loring, A. Papaspyros, and G.C. Stephens. 1972 The Hamburg Klippe reconsidered: *American Journal of Science*, Vol. 272, p. 305-318.

Riva, J. 1969. Middle and upper Ordovician graptolite faunas of St. Lawrence lowlands of Quebec and Anticosti Island: *in*: Kay, M., ed., *North Atlantic geology and continental drift*: American Association of Petroleum Geologists Memoir 12, p. 513-556.

Riva, J. 1974. A revision of some Ordovician graptolites of eastern North America: *Paleontology*, Vol. 17, p. 1-40.

Ross, Jr., R.J., and S.M. Bergstrom, eds. 1982. *The Ordovician System of the United States*: Correlation chart and explanatory notes: International Subcommission on Ordovician stratigraphy. Publication No. 12. 73 p.

Ruedemann, R. 1947. *Graptolites of North America*: Geological Society of America Memoir 19. 620 p.

Skevington, D. 1969. Graptolite faunal provinces in Ordovician northwest Europe: *in*: Kay, M., ed., *North Atlantic geology and continental drift*: American Association of Petroleum Geologists Memoir 12, p. 557-562.

Skevington, D. 1974. Controls influencing the composition of Ordovician graptolite faunal provinces: *in*: Richards, R.B., D.E. Jackson, and C.P. Hughes, eds., *Graptolite Studies in Honor of O.M.B. Bullman*. Special Papers in Paleontology, Vol. 13, p. 59-73.

Stephens, G.T., T.O. Wright. 1981. Stratigraphy of the Martinsburg formation, west of Harrisburg in the Great Valley of Pennsylvania: *American Journal of Science*, Vol. 281, p. 1009-1020.

Stephens, G.T., T.O. Wright, and L.B. Platt. 1982. Geology of the middle Ordovician Martinsburg formation and related rocks in Pennsylvania: Guidebook for the *47th Annual Field Conference of Pennsylvania Geologists*, distributed by the Pennsylvania Geological Survey, Harrisburg, Pennsylvania. 87 p.

Weller, S.B. 1903. *The Paleozoic faunas*: New Jersey Geological Survey Report on Paleontology, Vol. 3, 462 p.

Whittington, H.B. 1968. *Cryptolithus* (Trilobita). Specific characters and occurrence in Ordovician of eastern North America: *Journal of Paleontology,* Vol. 42, No. 3, p. 702-714.

Willard, B., 1943. Ordovician Clastic Sedimentary Rocks in Pennsylvania. *Geological Society of America Bulletin,* Vol. 54, No. 8, p. 1067-1122.

Willard, B., 1949. An Eden Faunule in New Jersey: *Journal of Paleontology,* Vol. 23, No. 2, p. 218-224.

Wright, T.O., S.M. Garwood, and K. Derstler. 1977. The age of the Martinsburg formation at Swatara Gap, Pennsylvania: *Pennsylvania Academy of Sciences Proceedings,* Vol. 51, p. 85-87.

Wright, T.O., and G.C. Stephens, 1978. Regional implications of the stratigraphy and structure of Shochary Ridge, Berks and Lehigh Counties, Pennsylvania. *American Journal of Science,* Vol. 278, p. 1000-1017.

Wright, T.O., G.C. Stephens, and E.K. Wright. 1979. A revised stratigraphy of the Martinsburg formation of eastern Pennsylvania and paleogeographic consequences: *American Journal of Science,* Vol. 279, p. 1176-1186.

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APPENDIX -- NEW FAUNAL SITE DESCRIPTIONS

INTRODUCTION

Here we describe the location and give the faunal lists for each site. There is also a discussion on the correlation of each locality. Some of the localities contain only shelly fauna, others only graptolitic fauna. Several have a mixed fauna. The numbers associated with the specimens listed, unless otherwise stated, are New Jersey State Museum (NJSM) accession numbers for the geological collections. This material is available for inspection upon request. The sites described in this appendix are marked on Fig. 1 in the main text.

LOCALITY DESCRIPTIONS

Locality Om-1
Martinsburg Formation
Bushkill Member

Location: West side of State Highway 206 at milepost 117, approximately one kilometer north of junction with county Route 519 in Branchville Boro, Sussex County, New Jersey (Culvers Gap Quadrangle).

Fauna:	*Cryptolithus tessellatus* Green	12554
	Plectorthis sp.	12555
	Climacograptus sp.	12678

Correlation: The presence of *C. tessellates*, long considered to be characteristic of the historical Trenton Stage, is significant. Designated as morphotype A of Lesperance and Bertrand (1976), the species indicates the Shermanian Stage of current usage. The approximate graptolite zone equivalents would be *Corynoides americanus* - *Climacograptus spiniferus* zones of Riva and *Orthograptus truncatus intermedius* - *Orthograptus quadrimucronatus* zones of Berry. The species has also been recorded from the Jacksonburg Formation which underlies the Bushkill Member (NJSM 6260). The Jacksonburg Formation in this area, along with a substantial portion of the Bushkill Member of the Martinsburg Formation, can be assigned a Shermanian Age. The graptolite facies equivalents cannot yet be determined.

Locality Om-5
Martinsburg Formation
Ramseyburg Member

Location: In the bed of Slateford Creek, approximately one kilometer upstream from its intersection with State Highway 611, and 100 meters downstream from a small dam, in Upper Mount Bethel Township, Northampton Country, Pennsylvania (Stroudsburg Quadrangle).

Fauna:	*Orthograptus ruedemanni*	12846
	Orthograptus cf. ruedemanni	12630,12772,12801,12802 12803,12845,12919,12920
	Orthograptus sp.	12651,12652,12653,12657

Correlation: *Corynoides americanus* Zone or *Orthograptus ruedemanni* zone of Riva (believed equivalent by some authors.) This would approximately correlate to the middle portion of the Shermanian Stage.

Locality Om-6
Martinsburg Formation
Bushkill Member

Location: Old quarry in streambed on the west side of State Highway 611, approximately one kilometer south of the intersection of Slateford Creek and the highway. Upper Mount Bethel Township, Northampton County, Pennsylvania. Quarry #28 of Epstein (1970) (Portland Quadrangle).

Fauna:	*Orthograptus* sp.	10853,12623,12624,12625 (in part)
	Glyptograptus sp.	12625 (in part)

Correlation: Uncertain, perhaps within the *Diplograptus multidens* Zone of Riva, which would be approximately equivalent to the *Orthograptus truncatus intermedius* zone of Berry. No equivalent in shelly facies may be hypothesized.

Locality Om-10
Martinsburg Formation
Ramseyburg Member

Location: Old quarry on the west side of the Millbrook-Blairstown Road, approximately 3.2 kilometers south of Millbrook, in Hardwick Township, Warren County, New Jersey. (Flatbrookville Quadrangle).

Fauna:	*Cryptolithus lorettensis* Foerste	12714
	Crinoidea (columnals)	11257
	Brachiopoda, indeterminate	14472

Correlation: The *Cryptolithus* specimens, which are an assemblage within Morphotype C (Morphtotype Association, III.1) of Lesperance and Bertrand (1976), are of notably small size. The correlation would be similar to that of the notable Swatara Gap fauna (*Climacograptus spiniferus* Zone of the graptolite facies).

Locality Om-20
Martinsburg Formation
Bushkill Member

Location: Road exposure and small quarry on the south side of Morris Avenue, approximately one kilometer northeast of its intersection with Sussex County Route 655 (Morris Turnpike) and .7 kilometer south of United States Highway 206, in Frankford Township, Sussex County, New Jersey (Culvers Gap Quadrangle).

Fauna:	*Glyptograptus* sp.	12581
	Climacograptus sp.	12584,12585,12663
	Diplograptus cf. *multidens* Elles and Wood	12659,12660
	Orthograptus or *Glyptograptus* sp.	12661,12662,12665
	Prolobella trentonensis (Conrad)	12629,12664

Correlation: Correlation to the *Diplograptus multidens* zone of Riva (1969, 1974) appears likely. This would be approximately equivalent to the *Orthograptus truncatus intermedius* zone of Berry (1962, 1970, 1971).

Locality Om-21
Martinsburg Formation
Ramseyburg Member

Location: Exposure in bank above Flatbrookville-Stillwater Road, just uphill from a sharp bend in the road at the 1080 foot contour, on the southeast side of Kittatinny Mountain. Locality previously published by Willard (1949). (Flatbrookville Quadrangle).

Fauna:	Brachiopoda, cf. Sowerbyella	14473
	Brachiopoda, cf. Resserella	14474
	Crinoidea (columnals)	14475

Materials previously published by Willard (1949) were cited as:

Crinoidea (columnals)
Cornulites sp.
Dinorthis sp.
Sowerybella rugosa (Meek)
Resserella multisecta (Meek)
Cryptolithus bellulus (Ulrich)

The repository of the materials is presently unknown.

Correlation: Although no *Cryptolithus* specimens have been found at the site in recent years, Willard's (1949) identification may be tentatively accepted, but it is uncertain whether his specimens would be considered *C. bellulus* by current standards. The specimens from Swatara Gap, now regarded as *C. lorettensis* were considered by some authorities to be *C.*

bellulus (Whittington, 1968, Epstein *et al.*, 1972). The fauna probably resembled that of Locality Om-10, correlated with the Swatara Gap fauna and with the *Climacograptus spiniferus* zone of graptolite facies.

Locality Om-22
Martinsburg Formation
Bushkill Member

Location: Embankment on west side of road just north of the intersections of County Routes 521 and 612 in Middleville, Stillwater Township, Sussex County, New Jersey (Newton West Quadrangle).

Fauna:	*Glyptograptus euglyphus* Lapworth	12586,12591,12592,12599 12604,12612,12613,12744,12745
	Nautiloidea	12590,12596,12563
	Prolobella *trentonensis* (Conrad)	12614,12753
	Murchisonia sp.	12595
	Plectorthis sp.	12589
	Gastropoda	12684
	cf. Cornulites sp.	12791
	Brachiopeda	12747
	Gastropoda, cf.	12749
	Pelecypoda, cf.	12748
	Crinoidea	

Correlation: *Glyptograptus euglyphus* ranges from the *C. teretiusculus* zone up to high in the *C. bicornis* zone, up to approximately the *D. multidens* zone of Riva, (S. Finney, personal communication). The shelly taxa are similar, if not completely identical, to species known from the Jacksonburg Formation, which underlies the Martinsburg Formation at Locality Om-22 by less than ten meters. It appears likely that this important fauna belongs to the *C. bicornis* zone of Berry and is only slightly younger than the youngest of the graptolite localities of the Jutland Klippe to the south. It is probably the oldest fauna from the Martinsburg Formation in the area of study and particularly important for the presence of a shelly fauna among abundant graptolites.

Locality Om-26
Martinsburg Formation
Bushkill Member

Location: Road cut on west side of Sussex County Route 610, one kilometer southeast of milepost 3, at junction with Verdona Road, .7 kilometers northwest of State Route 94, Fredon Township, Sussex County, New Jersey (Newton West Quadrangle).

Fauna:	*Orthograptus* sp.	12628

Correlation: Uncertain, only one specimen is known from the locality. The presence of even one graptolite is unusual, as the lower Martinsburg Formation is atypically very calcareous in this exposure.

Locality Om-27
Martinsburg Formation
Pen Argyl Member

Location: Gully in the northwest corner of the Bangor Fidelity Quarry in Plainfield Township, Northampton County, Pennsylvania (Stroudsburg Quadrangle).

Fauna:	*Climacograptus spiniferus*	12637,12638,12848
	Climacograptus cf. *spiniferus*	12633,12688,12697
	Orthograptus sp.	12636,12686,12689,12694

Correlation: This fauna contains abundant graptolites but deformation has rendered most of the specimens unidentifiable. It is an especially important fauna, however, since it is the only one from the Pen Argyl Member within the area considered here. It is the northeastern most fauna ever reported from the member, occurring near the limit of exposure of the lithostratigraphic unit. It would seem to correlate with the *Climacograptus spiniferus* zone of Riva and probably to the Edenian Stage.

Locality Om-29
Martinsburg Formation
Ramseyburg Member

Location: Road cut on south side of the road which ascends to the upper reservoir of the Yards Creek Pump Storage Project, at the level of the 1180 foot contour, in Blairstown Township, Warren County, New Jersey (Bushkill Quadrangle).

Fauna:	Trilobita, indeterminate	12675
	Crinoidea, indeterminate	12674

Correlation: Uncertain.

Locality Om-30
Martinsburg Formation
Ramseyburg Member

Location: Outcrops on the north side of the pipeline, of the Yards Creek Pump Storage Project, at the level of the fourth concrete foundation west of the picnic parking area, in Blairstown Township, Warren County, New Jersey (Bushkill Quadrangle).

Fauna:	*Orthograptus quadrimucronatus* (Hall)	12672,12779,12792 12795,12797
	Orthograptus calcaratus (Lapworth)	12673
	Orthograptus sp.	12669,12670,12671 12673,12776,12777,12778

Correlation: The species are long-ranging forms which of themselves do not provide very specific age information. However, *O. quadrimucronatus* does not range as old as the youngest known occurrences of *Glyptograptus* *euglyphus* (Finney, personal communication) which confirms that this is a younger assemblage than that of Locality Om-22. It may be tentatively correlated with the *Orthograptus ruedemanni* zone of Riva on the basis of stratigraphic placement and faunal consistency with Locality Om-5, which is also in the Ramseyburg Member.

Locality Om-31
Martinsburg Formation
Bushkill Member

Location: Abandoned quarry near the top of a hill about one kilometer northeast of Branchville, New Jersey at 870 foot contour. The access is from Fox Hill Road, in Frankford Township, Sussex County, New Jersey. Locality previously published by Weller (1903) as his locality 75B.

Fauna: *Glyptograptus* sp. 12667

The fauna previously cited by Weller (1903) includes the following species.

Diplograptus folliaceus (Murchison)
Diplograptus angustifolius (Hall)
Lasiograptus mucronatus (Hall)
Corynoides calicularis Nich
Dalmanella testudinaria Dalman

In addition, the following specimens (which probably came from Weller's original collections) are deposited at the New Jersey State Museum:

Diplograptus (*Lasiograptus*) cf. *eucharis* 10757
Dicellograptus smithi 10760

Weller's specimens were restudied by Ruedemann (1947), who had performed the original identifications. The faunal list contained specimens from the Jutland Klippe as well as this locality, thus it is difficult to determine which specimens came from each area. Unfortunately, the specimens cannot be found at present, so a full re-examination is not possible.

It is difficult to interpret the fauna as given by Weller and Ruedemann without re-examination of the original specimens. Here we list a few ideas about this founa:

- It is unclear what Reudemann meant by *D. foliaceus* and *D. angustifolius* (see Reudemann, 1947).
- *Lasiograptus mucronatus* would now be considered *Hallograptus mucronatus*, said by Riva (1974) to be characteristic of his *D. multidens* zone.
- *Corynoides calycularis* (*calicularis*) ranges from the *N. gracilis* to the *C. americanus zone*, being particularly characteristic of the *D. multidens* and *C. americanus* zones.
- *Lasiograptus eucharis* was said by Ruedemann (1947) to range widely.
- *Dicellograptus* is not found in any sites younger than the *Diplograptus multidens* zone of Riva.
- The best correlation based on all the information, is an age equivalent to the *D. multidens* zone of Riva.

Correlation: It appears that the original collections were mishandled to some extent, and confusion will result from any examination or restudy of any materials alleged to come from this locality. New collections should be made, and no correlation proposed until that is done.

Locality Om-32
Martinsburg Formation
Bushkill Member

<u>Location</u>: Road cut on south side of Fredon-Greendell Road (Sussex County Route 608) about .2 kilometers northwest of intersection with Wintermute Road (Sussex County Route 519) in Fredon Township, Sussex County, New Jersey (Newton West Quadrangle).

<u>Fauna</u>: cf. *Orthograptus* sp. 12685

<u>Correlation</u>: Uncertain, fauna inadequate for determination.

Locality Om-33
Martinsburg Formation
Ramseyburg Member

<u>Location</u>: West side of Mattison Avenue, .3 kilometers south of intersection with Dennis Phillips Road (turn in Mattison Avenue roadway) and near Branchville Reservoir in Frankford Township, Sussex County, New Jersey (Branchville Quadrangle).

<u>Fauna</u>: *Orthograptus* sp. 12774,12918
(possibly *O. amplexicaulus O. calcaratus*)

<u>Correlation</u>: Uncertain, fauna as yet insufficient for determination.

Locality Om-34
Martinsburg Formation
Ramseyburg Member

<u>Location</u>: Roadcut on southside of Sussex County Route 628 about .3 kilometres east of the east end of Berry Road and west of the junction with Sussex County Route 635, in Wantage Township, Sussex County, New Jersey (Branchville Quadrangle).

<u>Fauna</u>: Brachiopoda, indeterminate and 14476
Crinoidea, indeterminate

<u>Correlation</u>: Uncertain, fauna as yet insufficient for determination.

Locality Om-35
Martinsburg Formation
Ramseyburg Member

<u>Location</u>: Median divider of roadcut for Interstate Highway 84, about 4 kilometeres east of Port Jervis and 1 kilometer east of the rest area in westbound lanes near the Kittatinny Mountain Summit in Greenville Township, Orange County, New York (Unionville Quadrangle).

<u>Fauna</u>:	Brachiopoda, indeterminate	12771
	Promopaleaster sp.	12770

This fauna was found about 50 meters below the Shawangunk Formation contact. A previously published fauna (Berry, 1971) was from approximately 30-60 metres below the Shawangunk Formation in the same locality. The fauna reported by Berry (1971) contained the following species.

Climacograptus spiniferus Ruedemann
Climacograptus typicalis Hall
Dicranograptus ramosus Hall
Orthograptus quadrimucronatus var. *approximatus* (Ruedemann)

<u>Correlation</u>: The graptolites are indicative of the *Climacograptus spiniferus* zone or sub-zone as used by Berry (1971), and the shelly fauna probably falls within that zone also. The asteroid genus *Promopaleaster* is also present at Swatara Gap, Pennsylvania which also correlates to the *Climacograptus spiniferus* zone (Wright *et al.*, 1977).

Locality Om-36
Martinsburg Formation
Ramseyburg Member

Location: South side of Yards Creek Pump Storage Project pipeline at fourth concrete foundation north of northwest corner of the picnic parking area in Blairstown Township, Warren County, New Jersey (Bushkill Quadrangle).

Fauna: *Orthograptus quadrimucronatus* (Hall)
Orthograptus sp. 12799

Correlation: The bed may be identical with that of Om-30, which is on the opposite side of the pipeline. The fauna and preservation are consistent. Tentatively, it may be considered a probable correlative of the *Orthograptus ruedemanni* zone of Riva.

Locality Om-37
Martinsburg Formation
? Bushkill Member

Location: Old quarry just south of Washburn Road near a creek crossing and railroad tracks, and along a farm road, in Mansfield Township, Warren County, New Jersey (Washington Quadrangle).

Fauna: *Plectorthis plicatella* (Hall) 14477

Correlation: This is the only faunal locality thus far reported from one of the Martinsburg Formation outliers (which lie geographically between the main body of outcrops and the Jutland Klippe). The abundant fauna consists of essentially one species, which is also found in the underlying Jacksonburg Formation. This would be consistent with a low position in the section and a relatively early age.

Locality Om-38
Martinsburg Formation
Ramseyburg Member

Location: East side of Mountain Road (Sussex County Route 519), just south of Glen Road intersection, in Wantage Township, Sussex County, New Jersey (Port Jervis South Quadrangle).

Fauna:	Brachiopoda, indeterminate	14478
	Crinoidea, indeterminate	14479

Correlation: Uncertain; fauna insufficient for determination.

Locality Om-39
Martinsburg Formation
Ramseyburg Member

Location: North side of Glen Road, at topographic high point about midway along the road, in Wantage Township, Sussex County, New Jersey (Port Jervis South Quadrangle).

Fauna:	Brachiopoda, indeterminate	14480
	Crinoidea, indeterminate	14481

Correlation: Uncertain; fauna insufficient for determination.

Locality Om-40
Martinsburg Formation
Ramseyburg Member

Location: West side of Sussex County Route 519, (a possible quarry) about .4 kilometers south of New York State line, in Wantage Township, Sussex County, New Jersey (Port Jervis South Quadrangle).

Fauna: *Orthograptus quadrimucronatus* 13838 13839 13840

Correlation: The fauna is similar to that of Locality Om-30 and the stratigraphic position is similar. The tenative correlation is to the *Orthograptus ruedemanni* zone.

Errata Sheet
New Biostratigraphic Information on the Ordovician Martinsburg Formation of New Jersey and Adjacent Areas
by
David C. Parris and Kenneth M. Cruikshank

Corrections

Page 16: "microscopic" for "miscroscipic"

Page 26: "and" for "amd"

Page 27: "*tessellatus*" for "*tessellates*"

Page 29: "Morphotype" for "Morphtotype"

Page 30: "*Prolobella*" for "*Prolobells*" (italicized)

Page 31: *Prolobella* and *Cornulites* should be italicized

Page 35: "Fauna" for "Founa"

POPULAR PUBLICATIONS IN PALEONTOLOGY: A GUIDE TO THE FOSSIL FIELD GUIDES

by
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One of my geology professors once warned his students against using the popular field guides, "whose only function," he claimed, "is to confuse and mislead the helpless amateur." While the proper identification of a mineral or a fossil may require Dana's Mineralogy or one of the Treatise on Invertebrate Paleontology volumes, it is often helpful to have some sort of illustrated guide book to aid in field determination of specimens.

Some field guides are better than others, especially for specific purposes. There are the true field guides whose basic raison d'etre is to provide collectors with visual reference systems for field identification. Then there are the so-called "range guides," books that are simply compendiums of fossil localities. Finally there are works that concentrate on techniques of finding, collecting and preparing fossils. Some publications attempt to be combinations of all three.

The recent renaissance of interest in paleontology, fueled by the technical debates over dinosaur endothermy, mass extinction theory, and evolutionary rates, has spawned a flood of new popular books on paleontology, including field guides.

I have selected a baker's dozen of these for review, with a view toward taking the hazard out of selecting a field guide or guides for those teachers or students not yet familiar with the rapidly expanding popular literature.

Ardvini, Paolo and Giorgio Teruzzi
1986 Simon and Schuster's Guide to Fossils. Simon and Schuster, Inc., New York, NY 320 pp.

This handsome paperback is profusely illustrated with lots of color plates, line drawings, and excellent graphics. There is a brief introductory section explaining in succinct but accurate fashion concepts such as fossilization, taphonomy, evolution, biostratigraphy and paleoecology. This is followed by an outline of taxonomic classification with lots of nice line drawings illustrating the various biological groups.

The overwhelming majority of the book is devoted to group-by-group description and illustration, starting with paleobotany and ending with fossil mammals. The lay-out is outstanding; on each pair of pages, the left-hand page contains descriptions of two genera, while the right-hand page has high-quality color photos of the described genera directly opposite. Thus there is no flipping back and forth between illustration and description, as with some field guides.

Another nice feature is the small colored graphics alongside each description depicting geologic time range and paleoenvironmental habitat for each genus. The coverage is extensive but not exhaustive; a nicely balanced job is done for plant, invertebrate, and vertebrate fossils. Each description contains a complete Linnean classification, a morphological analysis, stratigraphic range, and geographical distribution.

The only problem with this guide is that it is a translation of an Italian work, and thus its coverage of fossil forms emphasizes European specimens. Still, enough North American fossils and forms with cosmopolitan distribution are included to make the book a valuable reference, especially for its excellent specimen photographs. Also, this would be the field guide to take along on a fossil-hunting trip to Continental Europe or the Middle East!

(2)

Casanova, Richard and Ronald P. Ratkevich
1981 (3rd edition). An Illustrated Guide to Fossil Collecting. Naturegraph Publishers, Happy Camp, CA 240 pp.

This is the latest edition of Casanova's collecting guide, which first came out in 1957. The first chapter, entitled "The Romance of Fossil Collecting", is a fine summary of the history of paleontology. There is a short explanation of the different kinds of fossilization, followed by a chapter on the classification of fossil forms with short discussions and a few plates of each major taxonomic group. As in Ransom (1964), the treatment is too superficial to be of any real value except as an introduction to the organisms discussed.

A chapter on the history of life is next, then a good section on collecting fossils, with practical tips on collecting techniques for different rock types and various fossil groups.

Chapter 7 is a state-by-state listing of selected fossil sites. Coverage of western states (like California and Oregon) is good; but the eastern information is spotty. Much of the New Jersey information, for example, is either out of date or just plain wrong.

There is a good listing of museums, geological surveys, libraries with paleontological holdings, and paleonlogical societies. The book ends strongly with a good glossary and a nicely representative bibliography.

(3)

Goldring, Winifred
1960 Handbook of Paleontology for Beginners and Amateurs. Paleontological Research Institution, Ithaca, NY 394 pp.

This is a reissue of a 1929 classic by the former State Paleontologist of New York. The book has just been reprinted by PRI, and it seems to have withstood the test of time. Some of the terminology is outdated, but the book is useful for its illustrations and discussions of Lower Paleozoic fossils, especially forms from strata found in New York as well as in rocks of equivalent age in and around the Delaware Water Gap National Recreation Area.

The line drawings are excellent, and there are photographs of the old paleontologic dioramas in the New York State Museum at Albany. There is a thorough introductory section on the various forms of fossils (casts, molds, petrification, carbonization, tracks, etc.), and relatively complete sections on vertebrate fossils and paleobotany.

The extensive bibliography is chiefly useful for its citation of older classic references. The writing style is archaic, and there is not much detailed locality information, but it is nonetheless a charming addition to a fossil-hunter's library.

(4)

Hoskins, Donald M., Jon D. Inners, and John A. Harper
1983 Fossil Collecting in Pennsylvania. (2nd ed.). General Geology Report 40, Pennsylvania Geological Survey, Harrisburg, PA 215 pp.

While it is beyond the scope of this paper to review the many state fossil guides put out by the various state geological surveys, there is one guide book which is not only particularly relevant to our area, it is also an outstanding example of its type. This is Fossil Collecting in Pennsylvania, the official field guide published by that state's geological survey.

After a thorough but easily understood introductory chapter on the major fossil groups, there is an extensive listing of selected fossil localities covering most of the counties in the state, including the Delaware Water Gap region. The site descriptions include a detailed description of the precise location along with a topographic map indicating the fossiliferous spot, a discussion of the fossils found at the site with a faunal list, an explanation of the geology in the area, and a short list of references about the locality.

The end papers include a short bibliography, a list of fossil displays in Pennsylvania, and an excellent series of line drawings depicting the most common fossil genera found in Pennsylvania. For anyone doing paleontology in the Paleozoic deposits of the Appalachian mountains, this book is a must.

Lambert, David, and the Diagram Group
1983 A Field Guide to Dinosaurs. Avon Books, New York, NY 256 pp.

Billing itself as "The first complete guide to every dinosaur now known" (circa 1983), this book lives up to its subtitle. Unfortunately, the book's main title is something of a misnomer; this is not a very good field guide. There's lots of information about dinosaurs here, much of it presented graphically; black-and-white line drawings of skeletal material and restorations, numerous large-scale locality maps, and a series of dinosaur silouettes that are repetitive and generally uninformative.

The book is organized around an exhaustive listing of dinosaur genera grouped into families, with an introductory section about dinosaur evolution and behavior. There is very little about field technique or detailed locality information.

This might be a good gift for a young person fascinated by dinosaurs - although David Norman's recent (1985) Illustrated Encyclopedia of Dinosaurs covers the same territory more thoroughly, with lavish color graphics.

(6)

Lambert, David, and the Diagram Group
1985 The Field Guide to Prehistoric Life. Facts on File Publications, New York, NY 256 pp.

Produced by the same people who wrote A Field Guide to Dinosaurs this book is equally as useless as a true field guide. There is the usual perfunctory introduction, including brief discussions of fossils and fossilization, evolution, geologic time, taxonomic classification, and paleoecology.

The next eight chapters cover various fossil groups, but here the treatment is very lopsided; the fossils most likely to be found by most people in most areas of the country, plants and invertebrates, are dealt with very superficially in a chapter each, while very rare fossils, such as birds and amphibians, are given a chapter each.

The bias toward vertebrate remains is obvious. There's nothing wrong with that per se, but it insures that this volume will have minimum utility as a field guide. The final chapter makes an attempt at describing collecting and preparation techniques, but here too the discussion seems superficial. Even the graphics are not that helpful. Perhaps this book should have had a different title.

(7)

Macdonald, James Reid
1983 The Fossil Collector's Handbook: A Paleontology Field Guide. Prentice-Hall, Inc., Englewood Cliffs, NJ 193 pp.

Reid Macdonald is one of the legendary field workers in vertebrate paleontology, so it is not surprising that his book contains a great deal of useful information about field collecting. Macdonald offers practical tips and advice on everything from field notebook style to beer drinking, with lots of colorful anecdotes in between.

The heart of the book is chapter four, on "Collection, Preparation, and Curation." Included here are a list of supplies and equipment for field work, an excellent section on plaster jacketing large bones, washing matrix for small fossils, preparation of fossils in a home prep lab, casting specimens, shipping, and the organization and duties of a large field party such as might be mounted for a Western dinosaur dig.

The next chapter is a group-by-group description of various fossil organisms followed by a chapter on important fossil localities in the United States. This book has recently gone out of print, but one might find a copy in a library or used book store.

This is lamentable, because Macdonald has many amusing stories and lots of good practical field advice to offer.

(8)

MacFall, Russell P., and Jay C. Wollin
1983 Fossils for Amateurs (2nd ed.). Van Nostrand Reinhold Company, New York, NY 374 pp.

This book is strong on the technique of fossil-hunting and especially on the preparation, care, cataloging and display of specimens once out of the field and back in a collection. There is a very professional section on photographing fossil specimens with many useful tips on lighting and contrast. There is also a chapter specifically devoted to microfossils, a subject that is often neglected in most guides.

The general chapter on macrofossil classification is thorough and easily understood, and there are abundant half-tone plates to illustrate the different fossil groups. There are also chapters on such unusual topics as the value (in monetary terms) of fossils, and a "Fossil Finder" that supposedly helps a collector recognize difficult-to-identify specimens.

The appendices are very good with an excellent series of state geologic maps, an extensive bibliography, and lists of museums, geologic surveys, and fossil dealers. Despite the title, this work will prove useful to professionals for its thorough coverage of field techniques, fossil preparation, and collection management.

Moody, Richard
1986 __Fossils__. Macmillan Field Guides, Macmillan Publishing Company, New York, NY 192 pp.

This English work has many nicely reproduced color photographs of fossil specimens, with brief descriptions of each pictured genus on the page opposite the plate. There is a short introductory section which is quite good on collecting equipment and etiquette, the different modes of fossilization, evolution, sedimentary rocks and depositional environments.

An unusual feature of this book is a fossil identification key; while keys are commonly found in many natural history field guides, for some reason they do not appear in many fossil guides. The key provides a logical sequence of elimination until your mystery specimen can be attributed to its proper taxonomic category.

Since the author is English, the emphasis here is slightly slanted toward specimens common in the British Isles and Western Europe. However, for most of Phanerozoic time the British Isles have been closer to Eastern North America than at present, and the surprising number of fossil forms shared by the now geographically distant regions is another line of evidence used to support the paradigm of plate tectonics.

The book is worth having for its typically English excellent production values, and would be a good work to take along on a fossil collecting trip to Great Britain. A more complete set of fossil field guides with extensive line drawing illustrations for British fossils is the superb three-volume series __British Paleozoic Fossils, British Mesozoic Fossils,__ and __British Cenozoic Fossils__, published by the British Museum (Natural History).

(10)

Murray, Marian
1967 Hunting for Fossils. Macmillan Publishing Company, Inc., New York, NY 348 pp.

This is another "range guide" similar to Casanova and Ratkevich (1981) and Ransom (1964) in its attempt to present a comprehensive listing of fossil localities in all fifty states. Unfortunately it suffers from much the same deficiencies as the other two works. Coverage of individual fossil groups is sparse, with a chapter each on invertebrates and plants. There are a few photographs, and some line drawings scattered through the introductory portion of the text, but these do not suffice for practical identification purposes.

The best part of the introductory section is the chapter on finding and care of fossils (Chapter V) which contains a detailed account of the plaster jacketing technique for collecting large vertebrate material such as dinosaur bones. Little is said about techniques for collecting invertebrate fossils, by far the most common type of organisms found in the rocks of our region, but there are some useful tips for fossil plants.

The bulk of the book, as with the other "range guides", is concerned with listing specific sites in the fifty states of the U.S. The information for each state is broken down into three parts: a general geologic setting; a stratigraphic listing of fossil sites; and then a geographical discussion of localities, often county by county. Here again, as with the other "range guides", much of the information is out of date, and there are some glaring omissions. For instance, Murray does not mention in her section on Maryland the world famous Miocene exposures along the thirty-mile length of Calvert Cliffs on the western shore of Chesapeake Bay. Any listing of this sort is a very ambitious undertaking, and much of the information contained is bound to be purely historical in nature; the best way to use this book is as a rough indicator of what might be found in a particular state or region.

The appendices contain a good bibliography, with a general reference section and a state-by-state listing of publications, a good glossary, and lists of museums, universities and state geological surveys where one can obtain further information. As the "range guides" go, this is perhaps the best of an unimpressive lot.

(11)

Ransom, Jay Ellis
1964 Fossils in America. Harper and Row, New York, NY 402 pp.

Ostensibly a comprehensive and exhaustive "range guide" to fossil localities in the United States, this book has a few major flaws. The first part of the book contains a half-dozen introductory chapters on the nature of fossils, field collecting, organizing a collection, geologic time and geologic maps.

The chapter on identifying and classifying fossils presents a brief description of each major group along with a few nice line drawings of representative species. The problem here is that there is too little detail and not enough drawings to cover a topic as large as this.

The bulk of the book resides in the second part, which is a state-by-state listing of fossil sites. The information here can give one a general idea of what can be found in a particular county of a particular state, but much of the locality data was outdated even before the book was published. In the section on New Jersey sites, for example, the author lists localities that have been non-existent for decades. There is a good glossary, and an extensive list of reference libraries and museums.

(12)

Rhodes, Frank H.T., Herbert S. Zim, and Paul R. Shaffer
1962 Fossils: A Guide to Prehistoric Life. Golden Press, New York, NY 160 pp.

This is one of the Golden Nature Guide series, those small inexpensive field guides that have almost become an institution and are usually a child's introduction to reptiles, birds, fish or in this case fossils. There is a wealth of information packed into this little book, from the opening section on evolution, through the introductory discussion on fossils and how to collect them, to the summary of geologic time and group-by-group descriptions.

The historical discussion of fossil communities through geologic time is a nice, easily understood segment that describes life in each geologic period; there is a map associated with each period showing where rocks of that age outcrop in North America. The rest of the book is devoted to descriptions of the major fossil groups, with color drawings illustrating some of the more common genera. It is surprising to see how many of the forms pictured in this little book can be found in our region.

If you have a young niece or nephew who is interested in fossils, this would make an ideal Christmas or birthday gift; and it also would be the best choice for a teacher, operating on a limited budget, who wants to provide the students participating in a class fossil-hunting trip with their own field guides.

(13)

Thompson, Ida
1982 The Audubon Society Field Guide to North American Fossils. Alfred A. Knopf, Inc., New York, NY 846 pp.

Right now, the Audubon Guide is probably the best of the easily available popular fossil field guides, particularly for the northeastern United States region. Ida Thompson has taught at Princeton and Rutgers, and many of the fossil genera chosen for illustration and description in this work are commonly found in eastern North America, and especially New Jersey.

The introductory section includes discussions of types of fossils, geologic time, sedimentary rocks and summaries of evolutionary developments during each geologic period. There are careful instructions on how to make use of the guide, including a key to the thumb tab guide of the color photographic plates. The color plates are generally good but not always perfect; they are separate from the text, which necessitates some flipping back and forth from picture to description.

Other minor gripes include the overly "busy" geologic maps (which are smaller reproductions in black-and-white of the large geologic map of North America produced in color by the U.S.G.S.), and the lack of a bibliography.

The fossil genera descriptions are very good, and Thompson's wide knowledge of living marine forms comes through in her discussion of the paleoecology of the fossil forms. This commentary makes the specimen come alive for the reader, and there is much good information here. A set of simplified line-drawings identifying nomenclature used to describe each phylum's morphology and a section on collection and preparation round out the text, and the obligatory glossary and lists of museums and geologic surveys complete it.

A nice touch is a list of the localitits and museum repositories for each pictured specimen. Despite the minor complaints, I would say that if you can only buy one fossil field guide, get this one.

REGIONAL SETTING OF THE DELAWARE WATER GAP AREA

by

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Introduction

What follows is an extended abstract of a talk attempting to place the geologic history of the Delaware Water Gap Region in its appropriate place in Appalachian history. At the end, is a list of some of the more interesting unresolved questions and some suggestions of additional reading for those who want more detail.

Precambrian

The oldest rocks in the region are in the Precambrian crystalline basement which crops out in the Reading Prong-Jersey Highlands at the southern margin of the Great Valley. Although our understanding of the history of these rocks is incomplete, we do know that they had a complex history and were subjected to several metamorphic and deformational events, the most recent of which occurred about 1.1 billion years ago, and is known as the Grenville Event. These rocks formed the continental mass which began to break up in the latest Precambrian or earliest Cambrian to produce the Iapetus Sea.

Cambrian and Ordovician

As rifting progressed, an ocean basin began to develop, and the oldest Paleozoic rocks (Hardyston, Leithsville, Allentown, Rickenbach, Epler, and Ontelaunee) were deposited in relatively shallow water. Evidently, the basin initially subsided at roughly the same rate that sedimentation occurred. The rate of subsidence increased in the Ordovician, and the Jacksonburg and Martinsburg Formations were deposited in much deeper water. This deepening of the basin and influx of clastic sediments probably were related to the development of a subduction zone, the beginning of closure of Iapetus, and a tectonic event, the Taconic Orogeny.

Evidence for the Taconic Orogeny occurs throughout much of the Appalachian Orogen. The classic Taconic thrust slices of New England and the Hamburg Klippe of Pennsylvania provide impressive evidence of gravity sliding and thrusting. Additionally, the Taconic Unconformity, a regional, angular unconformity separating Silurian rocks from the underlying Ordovician rocks, provides clear evidence of Taconic deformation and erosion. Clearly, rocks of the Martinsburg Formation were deformed and eroded prior to deposition of the Silurian Shawangunk Formation. The extent of this deformation, its intensity, and whether or not cleavage development was associated with it is one of the unresolved controversies of the area.

Silurian and Devonian

In the Lower and Middle Silurian sediments shed from a source to the southeast formed a clastic wedge now known as the Shawangunk and Bloomsburg Formations. The long northeast-southwest extent of the outcrop belt suggests a linear source, although the precise location is still in doubt. In any case, this sequence of rocks generally fines upward, probably reflecting the erosion of the highlands produced in the Taconic Orogeny.

The Upper Silurian and Lower Devonian began as a time of quiet as the Poxono Island, Bossardville, Decker, Rondout, and Coeymans Formations were deposited in relatively shallow water. Subsequently, the basin deepened as the upper Coeymans, New Scotland, Minisink and Port Ewan Formations were deposited. The area emerged from the sea and the upper Port Ewan and Oriskany were deposited.

During the Lower and Middle Devonian, rapid subsidence occurred as the Esopus, Schoharie, Buttermilk Falls, and Marcellus Formations were deposited. The deepening of the basin and the influx of clastics of the Marcellus and Mahantango Formations probably reflect the final closure of the ocean basin in New England with its associated period of mountain building, the Acadian Orogeny. The extent of Acadian effects is still problematical, and the apparent lack of recognized Acadian effects in the Mid-Atlantic states is bothersome given the intensity of deformation, metamorphism, and igneous intrusion to the north and south. The Middle and Upper Devonian Marcellus through Catskill Formations are an Acadian clastic wedge and nearly repeat the conditions which produced the Taconic Clastic Wedge.

Carboniferous and Permian

As the mountains formed in the Acadian began to wear away, the low relief and warm climates allowed large coal swamps to develop. Rocks deposited during this period were deformed in the Permain, Alleghenian Orogeny, which marked the final closure of Iapetus. Alleghenian effects were dramatic in Pennsylvania and New Jersey. Clearly, all folding of post-Devonian, Paleozoic rocks can be assigned to the Alleghenian. There is still debate about how much other faulting and folding was associated with that event.

Mesozoic and Cenozoic

Mesozoic rifting reactiviated faults, triggered volcanism and igneous intrusion, and produced the large basins which step across the orogen in New Jersey and Pennsylvania making the correlation of some Paleozoic rocks difficult. These Mesozoic rift basins are thought to be associated with the opening of the modern Atlantic Ocean. Finally, the coast subsided and was mantled with unconsolidated sediments Cretaceous or younger in age. In the Pleistocene, glaciers advanced across the northern portion of the region, and meltwater streams deposited additional sediment over the southern portion of the region.

Interesting Problems

1) The scope of the Taconic Orogeny. It is clear that Taconic deformation occurred in the region, and most workers document major Taconic effects

along the entire Appalachian Orogen. Gray (1959), MacLachlan (1964), and Drake (1969, 1970, 1980) have argued for the formation of nappes during the Taconic to explain some of the complex geology in the Reading Prong and Great Valley.

2) The scope of the Alleghenian Orogeny. All of the folding in post-Devonian Paleozoic rocks is Alleghenian. Additionally, Drake (1978), Faill and MacLachlan (1980), Drake and Lyttle (1980), and others argue strongly that a sequence of nearly horizontal decollements linked by steep ramp faults developed during this period.

3) The age and cause of the prominent slaty cleavage in the Martinsburg Formation. A Taconic age was assigned by Drake and others (1960) and Maxwell (1962). Epstein and Epstein (1969), Lash (1978), and Epstein (1980) have presented evidence supporting an Alleghenian age for that cleavage.

4) The lack of recognized Acadian effects in this portion of the Appalachians when there are clear Acadian effects to the north and south.

5) Complete plate tectonic models for the Acadian and, especially, the Alleghenian. There is great agreement about rifting to produce Iapetus and that the beginning of closing of Iapetus is reflected in the Taconic Orogeny. Satisfactory models for the Acadian and Alleghenian have not yet been developed.

Other Reading

All of the foregoing is based on work by others, and a complete bibliography would be very long. The following represent some of the best summaries of the geology of the region.

Drake, Avery A., Jr., and Lyttle, Peter T., 1980, Alleghanian Thrust Faults in the Kittatinny Valley, New Jersey, in Manspeizer, Warren, Ed., Field Studies of New Jersey Geology and Guide to Field Trips: 52nd Annual Meeting of the New York State Geological Association. Newark, NJ: Rutegers University Press, p. 92-114.

Epstein, Jack B., 1980, Geology of the Ridge and Valley Province, Northwestern New Jersey and Eastern Pennsylvania, in Manspeizer, Warren, Ed., Field Studies of New Jersey Geology and Guide to Field Trips: 52nd Annual Meeting of the New York State Geological Association. Newark, NJ: Rutegers University Press, p. 70-89.

Epstein, Jack B. and Epstein, Anita G., 1969, Geology of the Valley and Ridge Province Between Delaware Water Gap and Lehigh Gap, Pennsylvania, in Subitzky, Seymour, Ed., Geology of Selected Areas in New Jersey and Eastern Pennsylvania and Guidebook of Excursions. New Brunswick, NJ: Rutgers University Press, p. 132-205.

Markewicz, Frank J. and Dalton, Richard, 1980, Lower Paleozoic Carbonates: Great Valley, in Manspeizer, Warren, Ed., Field Studies of New Jersey Geology and Guide to Field Trips: 52nd Annual Meeting of the New York State Geological Association. Newark, NJ: Rutegers University Press, p. 54-68.

Wolfe, Peter E., 1977, The Geology and Landscapes of New Jersey. New York: Crane Russak and Co., Inc.

EURYPTERIDS FROM A NEW LOCALITY IN THE SHAWANGUNK FORMATION, NEW JERSEY AND PENNSYLVANIA

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Abstract. A large suite of eurypterids has been collected from a new American locality--the upper member of the Shawangunk Formation (Silurian) near the Delaware Water Gap, New Jersey and Pennsylvania.

The fossils are in a matrix of dark grey and black shales. They are usually preserved as a tan colored carbonized film. All the specimens are fragmentary, whether they are molts or have been fragmented by depositional factors cannot be determined. Because all the fossils studied thus far are of small individuals--reconstructions indicate sizes from about 3 cm to 7 cm in length--a high percentage of molt fragments is likely.

Most specimens identified thus far are *Hughmilleria* cf. *shawangunk* Clarke. A few fragments display a pterygotid pitted ornamentation. Nautiloid cephalopods, a bivalve, and probable coprolites are associated with the eurypterids.

STRATIGRAPHY OF THE DELAWARE WATER GAP AREA

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Stratigraphic studies of the Delaware Water Gap area reveal interupted depositional cycles from the lower Cambrian to middle Devonian periods. Sedimentary environments include fluvial, near shore and off shore facies. Several unconformities indicating interuptions in the depositional cycles are attributed to local and regional tectonic activity. The Taconic, Acadian and Appalachian orogenies are reflected in regressive and erosional sequences during and after the formations were deposited.

DEVONIAN

Mahantango limestone
Marcellus shale
Buttermilk Falls limestone
Schoharie siltstone and shale
Esopus shale
Oriskany sandstone and limestone
Port Ewen limestone and shale
Minisink limestone
New Scotland limestone
Coeymans limestone

SILURIAN

Manlius limestone
Rondout limestone
Decker shale
Bossardville limestone
Poxono Island shale
High Falls sandstone and shale
Shawangunk conglomerate and sandstone

ORDOVICIAN

Martinsburg shale
Jacksonburg limestone
Kittatinney dolostone (Epler member)
Kittatinney dolostone (Rickenbach member)

CAMBRIAN

Kittatinney dolostone (Allentown member)
Kittatinney dolostone (Leithsville member)
Hardyston sandstone

ACADEMIC ALLIANCES

DR. FRED GOLDSTEIN

Academic Alliances are designed to foster communication and collaboration among faculty members in their common diciplines in schools, college and universitites in local areas. The North American Geological Alliance includes 85 members representing 40 states and several provinces in Canada. Further national and international conferences will include project directors from other disciplines. Perhaps we have some things to learn from as well as to contribute to our colleagues in the natural and social sciences.