USING MARINE FOSSILS TO UNLOCK THE MIDDLE DEVONIAN PALEOENVIRONMENTS OF WESTERN NEW YORK
(FOR K-12 TEACHERS AND COLLECTORS)

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INTRODUCTION

The physiographic province of the Allegheny Plateau offers a geologically rich visage of the Paleozoic prehistory of western New York State. The region possesses a relatively complete (and highly fossiliferous) section of Middle Devonian rocks. This section of Devonian strata thickens towards the east, directly reflecting the resultant sedimentation from the Acadian orogeny, and inspiring the name of the Catskill clastic wedge to the strata (Brett, 1986). As mountain building progressed to the east and southeast, most of New York State was covered by a shallow sea in what is known as the Appalachian Basin (Isachsen et al., 2000). During this time, the amount of sediments being deposited changed, the type of sediments changed, and local sea levels rose and fell. These paleoenvironmental fluctuations set the stage for major changes in the regional paleontology during the Middle Devonian.

This paper and the accompanying field trip seek to introduce science educators and fossil collectors to some interesting Devonian sites in western New York (Figure 1). The trip explores rocks chiefly from the Middle Devonian Hamilton Group, which represents a 5 to 7 million year time period between about 377 and 384 million years ago (Brett, 1986). The Hamilton Group includes four formations: the Marcellus, Skaneateles, Ludlowville, and Moscow. Formations within the Hamilton group are divided by three separate limestone units: the Stafford, Centerfield, and Menteth/Portland Point (Patchen and Dugolinsky, 1979; Brett, 1986). The Genesee Formation, which in some places overlies the Hamilton Group, is another important unit in understanding the regional geologic setting (Brett and Baird, 1994). The sequence of Devonian depositional events along with data from fossil assemblages helps us to characterize the "big picture" of the local geological history.

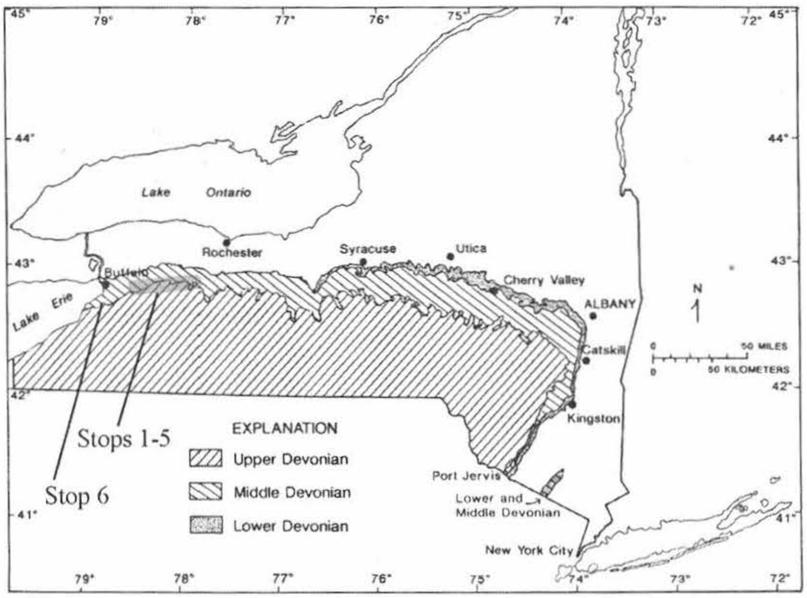


Figure 1. Location of Devonian strata in New York State with field trip area. Adapted from Isachsen, et al., 2000.

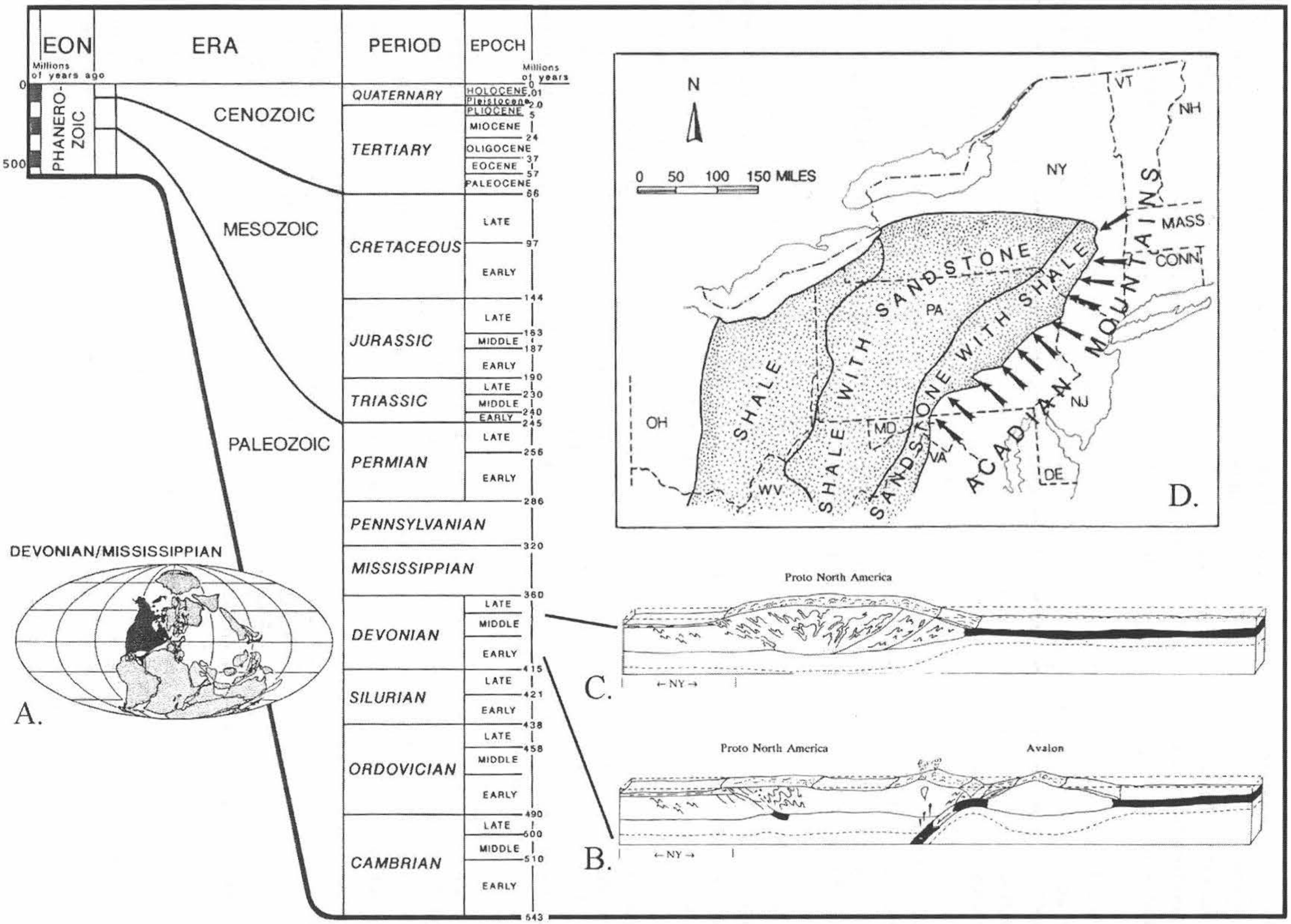


Figure 2. See explanation in section below. Modified from Isachsen, et al., 2000 and NYSE Earth Science References, 1999.

NEW YORK STATE DURING THE DEVONIAN

Early Devonian times saw the eastern shelf of the proto-North American continent covered by the Iapetus Ocean. New York State was also underneath a broad, shallow sea. The presence of thin limestone beds in central and eastern New York indicates that the landscape was relatively flat and free from sediment influx. Corals, bryozoans, crinoids, sponges, brachiopods, trilobites, and other marine inhabitants flourished during this time (Isachsen et al., 2000).

Sea levels dropped near the end of the Early Devonian, causing an erosional unconformity to form across much of New York. By about 390 million years ago, a shallow sea had returned to New York. Coral reefs and primitive fish dominated the paleoecology. The Onondaga Limestone represents a depositional period during the final hurrah of the placid marine environment. During this time several micro-continents were proximal to proto-North America, and closing (Figure 2A). The Early Devonian marked the shrinking of the Iapetus Ocean as its tectonic plate was being subducted beneath northeastern proto-North America (Figure 2B). About 390 million years ago, micro-continents known as the Avalon terranes crashed into proto-North America, resulting in the Acadian Orogeny (mountain building event). The collision lasted through the Middle Devonian (Isachsen et al., 2000).

By 380 million years ago, Avalon had "fused" to the North American craton (Figure 2C). Although parts of New York were slightly deformed by the collision, other parts of proto-North America experienced much greater deformation. The Acadian Orogeny had its greatest effects on present-day New England. Tall and extensive mountains formed to the east and southeast of New York (Figure 2D). The "rugged, lofty" Acadian mountains served as an excelled source of sediment for fluvial erosion (Isachsen et al., 2000). Rivers flowing from the Acadians deposited sands, silts, and clays over the shallow sea covering New York (arrows in Figure 2D). Thicker sections of sediment accumulated as the seafloor sunk (subsided). The "wedge" of sedimentary rock deposited during erosion of the Acadian Mountains is informally known as the "Catskill Delta" (Isachsen et al., 2000).

Fluctuations in local depositional conditions led to changing types of sedimentation throughout the Middle Devonian. The sedimentary record shows that the shorelines of the "Catskill Delta" of New York changed over time (Figure 3). This was due to several circumstances. One contributing factor was that the crust beneath the sea floor continually sunk as more sediment was loaded into the basin. Climate changes (such as increased/decreased precipitation) could have also played a role in the erosion rates of the Acadian Mountains. Also, the amount and types of sediment being eroded would have had a large influence on depositional conditions. All of these factors influenced a dynamic "Catskill Delta" shoreline during the Middle and Late Devonian (Miller, 1986; Isachsen et al., 2000).

Western New York State was relatively far from the "Catskill Delta" sediment source, and many of the Middle Devonian rocks reflect this relationship. The Hamilton Group contains four formations, each separated by a thin limestone bed. The Genesee Formation lies directly above the Hamilton Group and will also be explored in this trip (Figure 4). Rocks from these strata are dominantly shales and siltstones, with some thin limestones and coarse clastic beds (Brett, 1986; Brett et al., 1986; Brett and Baird, 1994; Isachsen et al., 2000).

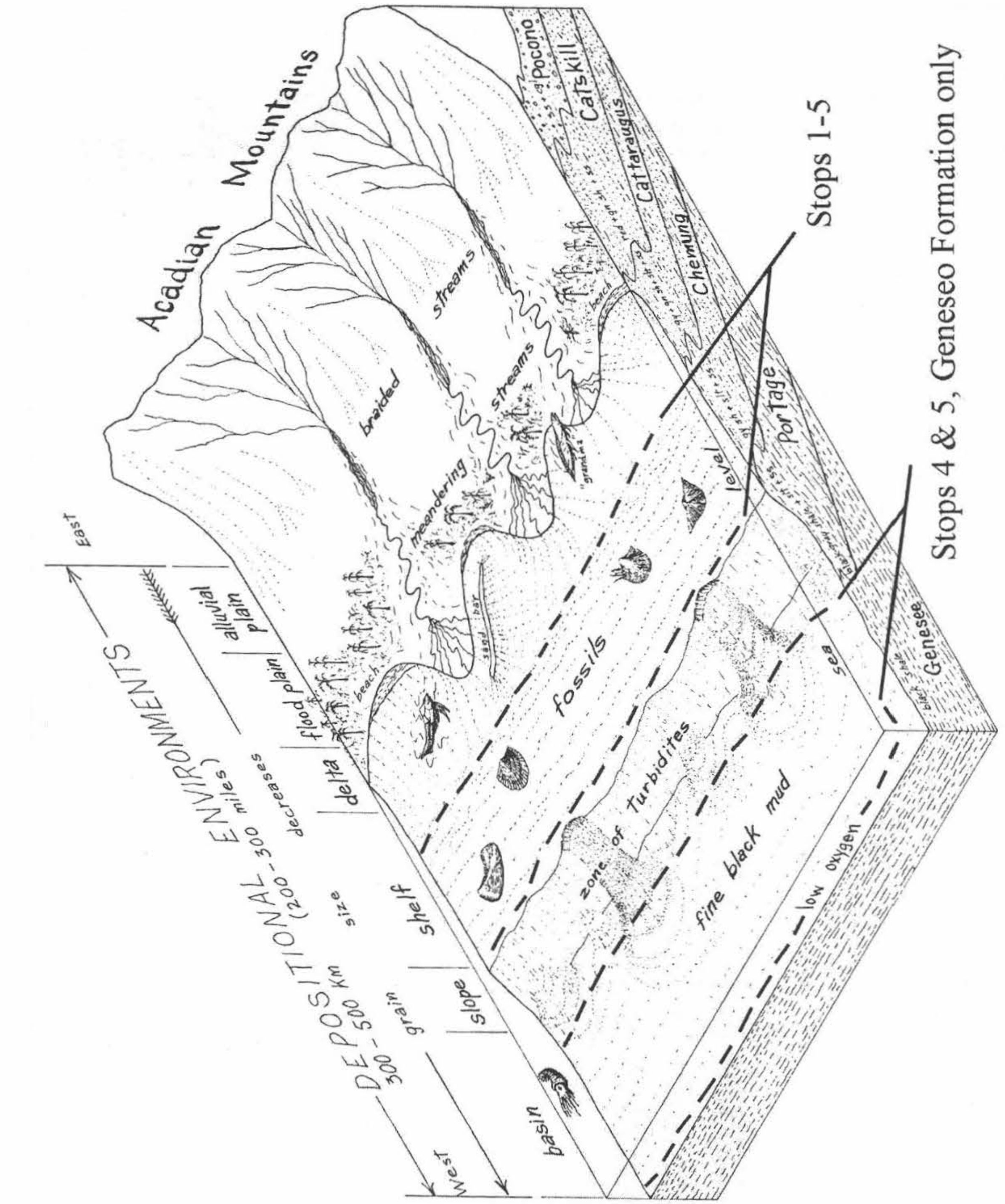


Figure 3. Characterization of "Catskill Delta" depositional settings. As deposition progresses outwards from the source of sediment, the physical energy of transport forces decreases, resulting in smaller clasts being carried. In this model, the relatively high energy streams, beaches, and deltas carry and deposit cobbles, pebbles, and sands; the medium energy offshore currents along the proximal shelf deposit sands; the lower energy currents along the distal shelf and slope deposit silts and clays; and the lowest energy currents in the basin deposit clays with some silts. Field trip sites are marked in their respective paleoenvironmental (but not necessarily geographical) provinces. Adapted from Isachsen et al., 2000.

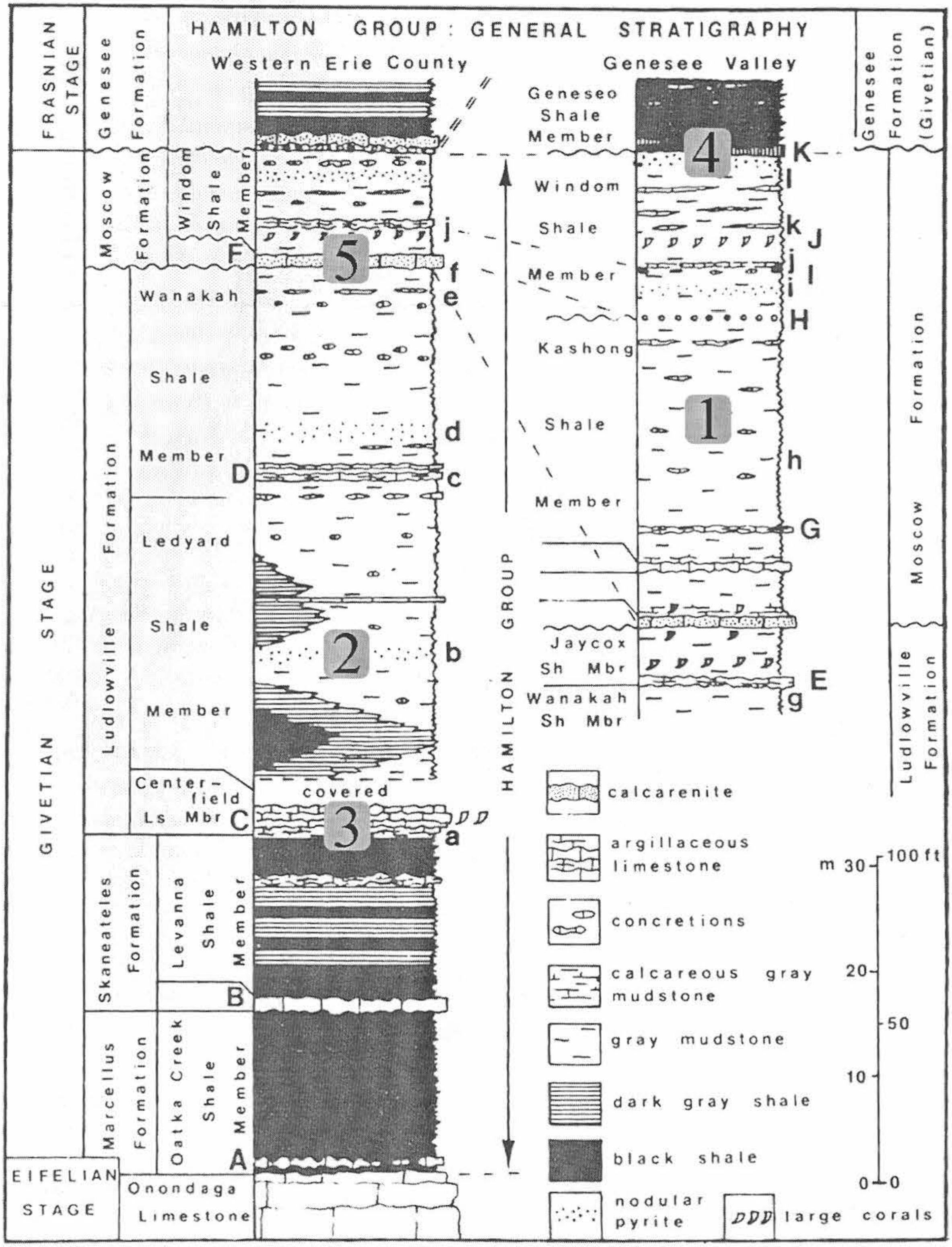


Figure 4. General stratigraphy of the Hamilton Group in western New York. Field trip locations are indicated in relation to their stratigraphic position. Important beds in this field trip include the: F) Tichenor Limestone; G) Menteth Limestone; K) Leicester Pyrite; and b) Alden Pyrite. Modified from Brett et al., 1986.

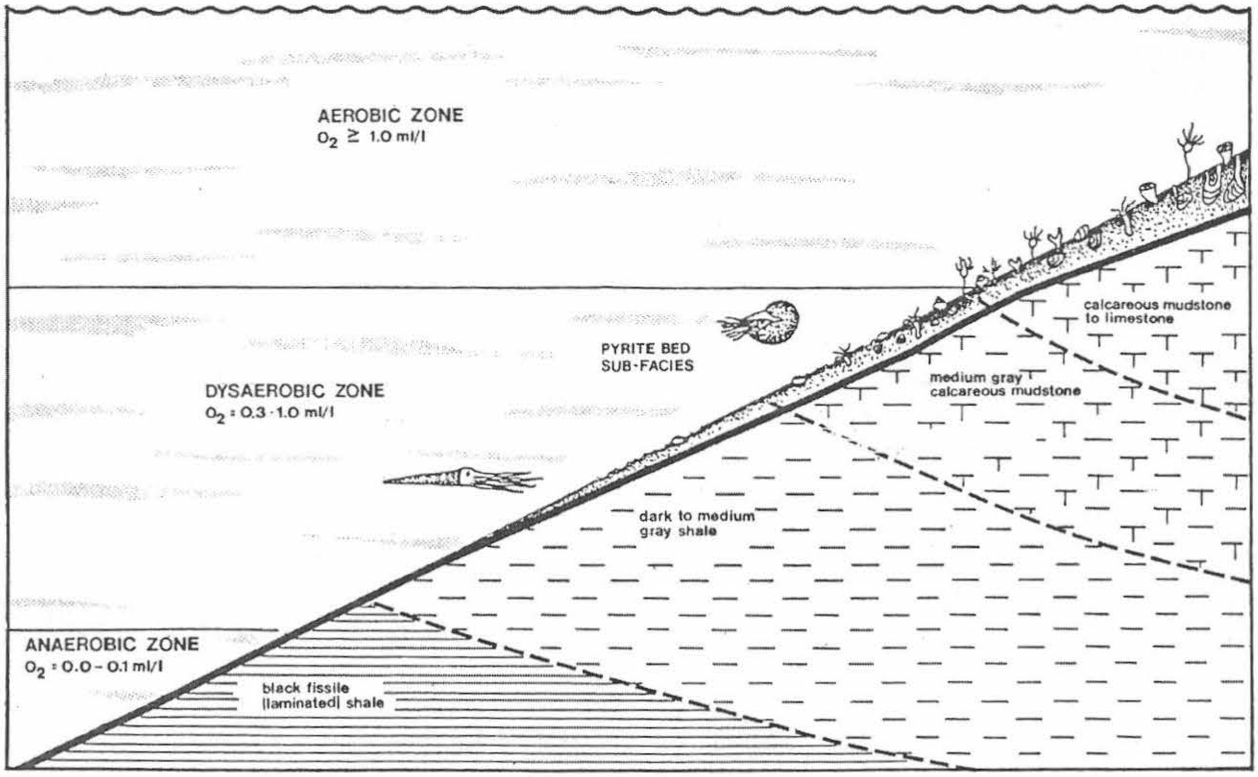


Figure 5. Oxygenation zones in Middle Devonian seas of New York. Generally, for the rocks on this trip, black shales are associated with the anaerobic zone (Facies I), gray shales with the dysaerobic zone (Facies II), and calcareous (limey) mudstones and limestones with the aerobic zone (Facies III/IV). Because of the lack of oxygen in the anaerobic zone, few marine organisms are able to exist. For those who live and die in this zone, the lack of oxygen prevents their immediate decomposition. The remaining organic matter can gradually become trapped hydrocarbons. The dysaerobic zone has a relatively limited supply of dissolved oxygen, and so few crinoids, corals, and bryozoans live in this zone. However, mobile animals such as fish and cephalopods flourish in the water above the dysoxic sea floor, as do some brachiopods and gastropods. Aerobic zones usually have a much greater diversity of life than other marine zones, and as a result the depositional environment tends to include a significant amount of calcium carbonate. For purposes of discussion within this paper, dysaerobic is synonymous with dysoxic, and anaerobic is synonymous with anoxic. Figure modified from Brett et al., 1991.

STOP 1: THE KASHONG SHALE

The Kashong Shale Member of the Moscow Formation is described as a bluish-gray mudstone (Brett and Baird, 1994). Deposition occurred in mostly shallow waters under aerobic conditions (Figure 5). At its thickest, the Kashong Shale is about 25 meters (80 feet) in the Genesee Valley (Figure 6). At Stop 1 (Retsof Locality), only the Middle Kashong is exposed. Common fossils from this unit are *Tropidoleptus carinatus*, *Nucleospira concinna*, *Mucrospirifer*, and *Athyris* (brachiopods); *Pleurodictyum americanum* (the patriotic tabulate coral); *Orthonota undulate* (bivalve); and *Dipleura* (trilobite). Many species of crinoids, blastoids, and bryozoans can also be found at this site. The bryozoans at this locality frequently encrust larger brachiopods and the numerous crinoids. Because bryozoans and crinoids need hardgrounds for larval attachment, this observation indicates that there was relatively little sediment input into the depositional system. Thus, the filter-feeders were forced to grow on other bottom-dwelling organisms (Brett and Baird, 1994).

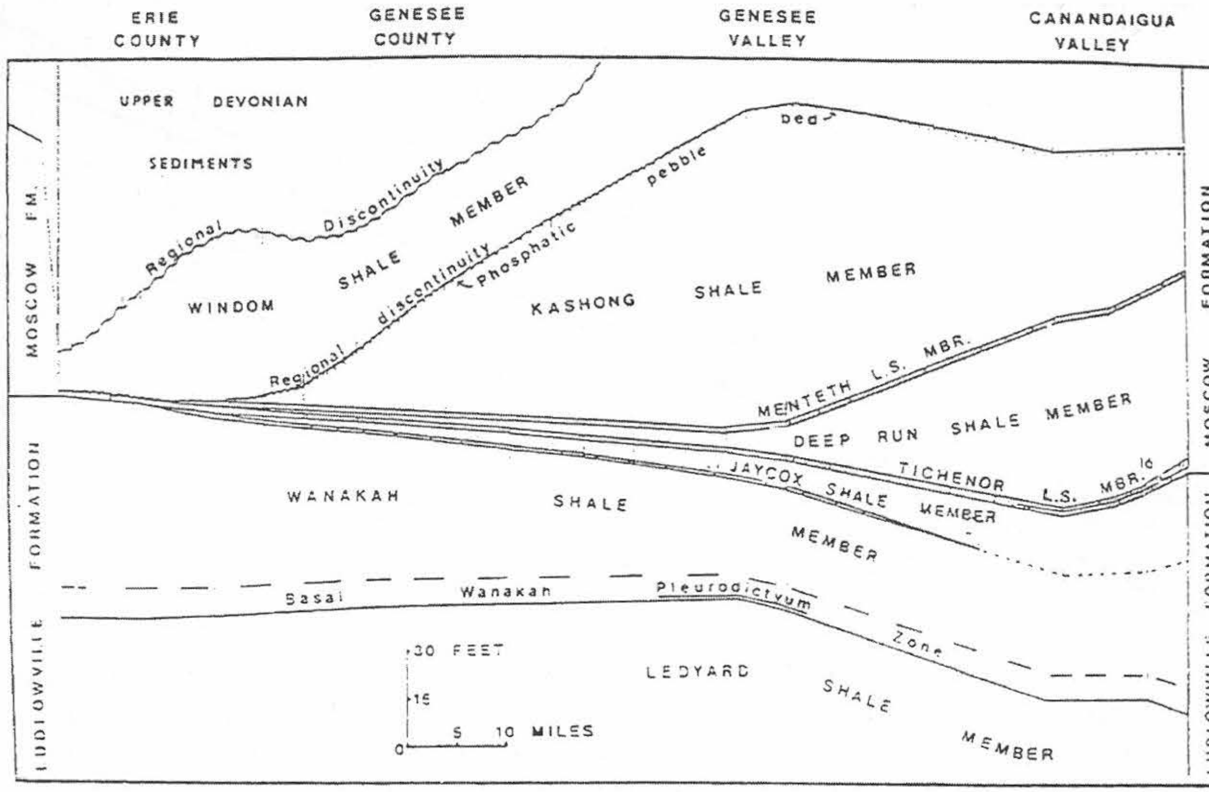


Figure 6. Cross-section of Ludlowville and Moscow Formations in western New York. Modified from Brett and Baird, 1994.

STOP 2: ALDEN PYRITE BED OF THE LEDYARD SHALE

The Ledyard Shale Member of the Ludlowville Formation is described as containing shales and argillaceous (clayey) limestones (Wygant 1986). The Ledyard Shale was deposited in deeper water than the Kashong Shale. Wygant (1986) classifies the Ledyard as a dysoxic sulfidic environment, meaning that there was a relative abundance of iron sulfide in relation to oxygen. These conditions led to the widespread deposition of pyritic beds in the Middle Devonian throughout western New York (Dick and Brett, 1986). Deceased organisms in these zones decomposed under low-oxygen conditions, leading to chemical processes that caused their hard parts to be replaced by iron pyrite. The Alden Pyrite Bed contains an abundance of pyritized trace and body fossils. Among the more common are brachiopods, bryozoans, corals, crinoids, bivalves, and trilobites (Wygant, 1986). Common species from this locality include *Phacops rana* (trilobite); *Tornoceras* (ammonite); and *Lingula*, *Mucrospirifer*, and *Devonochonetes* (brachiopods). Although there are many fossils to be found, the overall biodiversity of the Alden Pyrite is quite limited. Since the pyrite layer is located in a dysoxic zone (Figure 7), the faunal assemblage is not as diverse as it would be in a more oxygenated environment (Kloc, 1983; Dick and Brett, 1986). The local relationship of the Alden Pyrite Bed within the Ledyard Shale is shown in Figure 8.

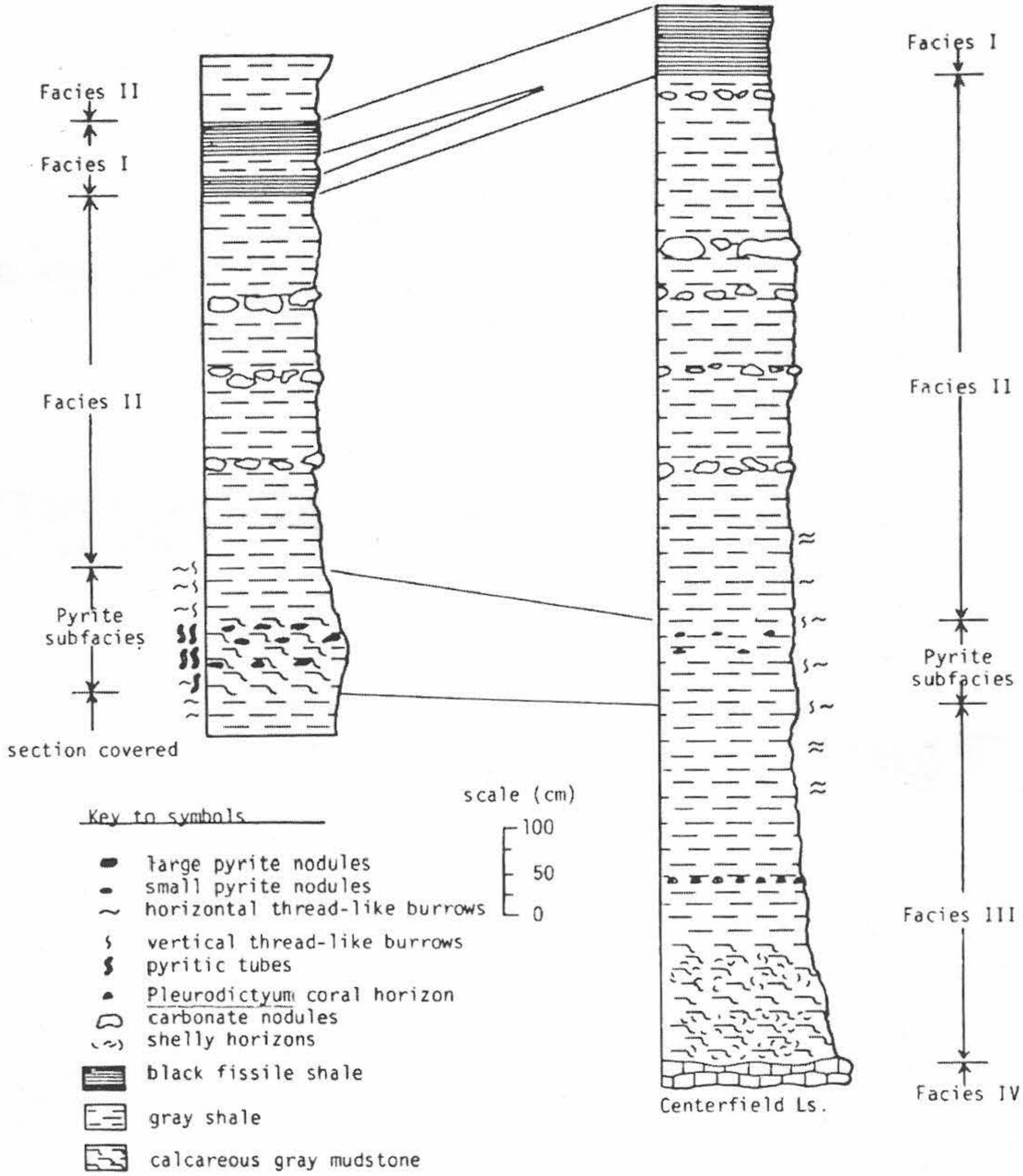


Figure 7. Stratigraphic sections showing two localities of the Alden Pyrite proximal to Stop 2. Adapted from Dick and Brett, 1986.

STOP 3: THE CENTERFIELD LIMESTONE

The Centerfield Member of the Ludlowville Formation is a "shale-limestone-shale" sequence similar to several other units within the Hamilton Group (Savarese et al., 1986). This trip visits the Centerfield limestone, which is sandwiched between upper and lower Centerfield shale units (Figures 8 and 9). Centerfield shales are typically light gray to gray-colored and calcareous, while the Centerfield limestones are approximately 70-80% calcium carbonate with some argillaceous (clay) content (Savarese et al., 1986). Stop 3 on this trip has exposures of weathered outcrop from the middle limestone, with over- and underlying units covered by

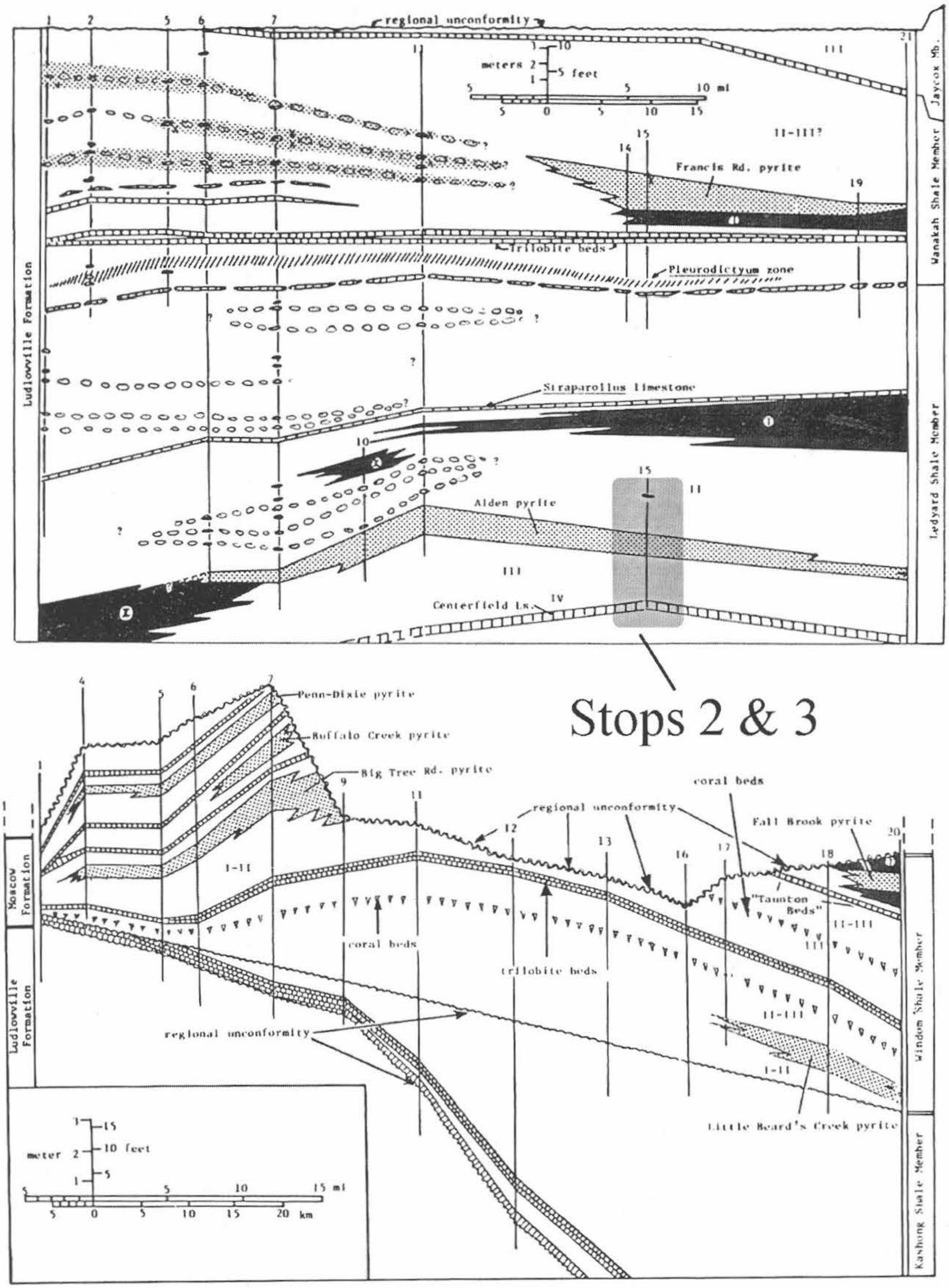


Figure 8. General stratigraphic sections for Stops 2 and 3. Adapted from Dick and Brett, 1986.

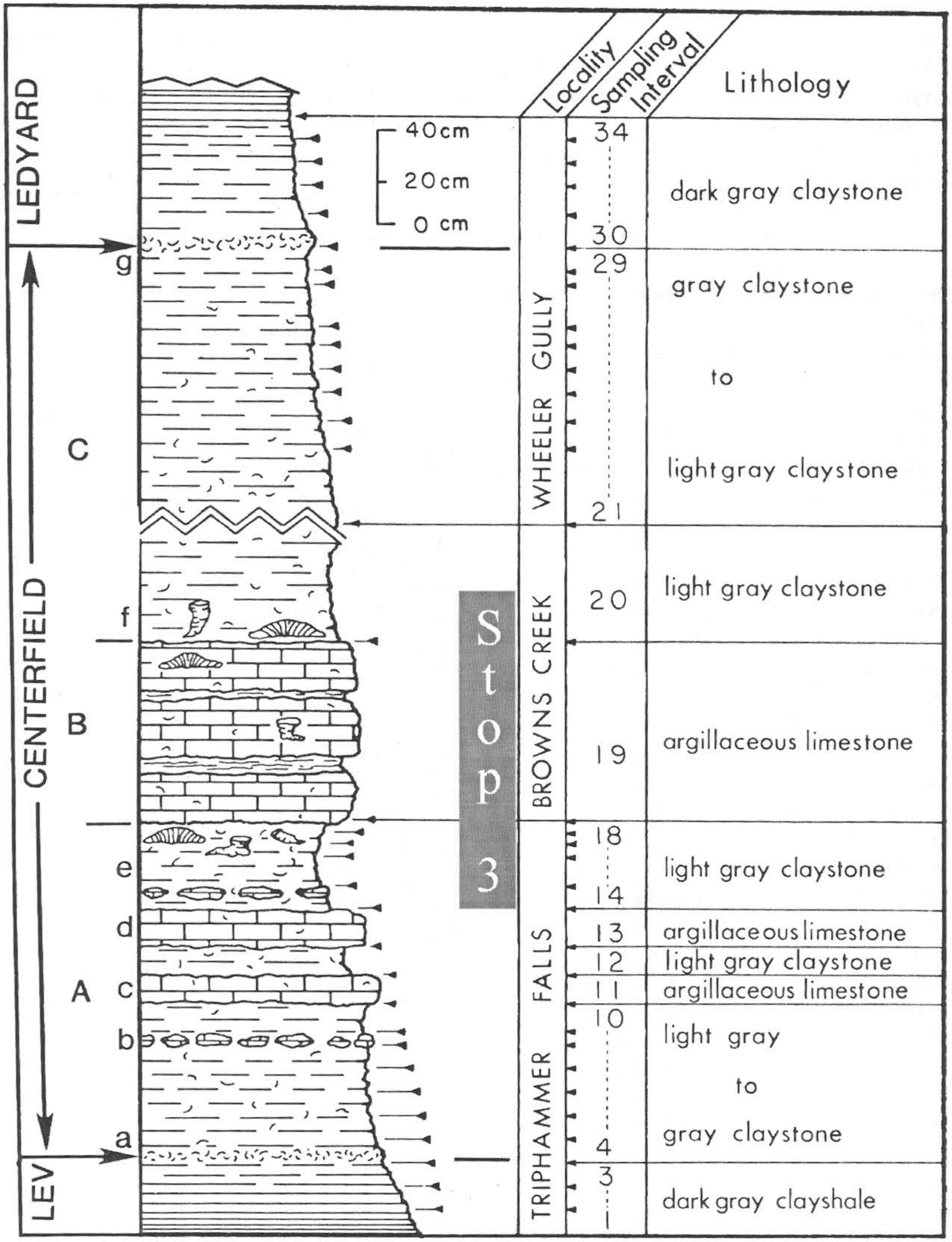


Figure 9. Local section for the Centerfield Member. Approximate stratigraphic zones for Stop 3 include sampling intervals 14 through 20. Modified from Savarese et al., 1986.

vegetation and slope wash. Common fossils at this stop include *Ambocoelia umbonata*, *Longispina mucronatus*, *Athyris*, *Mediospirifer*, and *Nucleospira* (brachiopods); *Heliophyllum*, *Cladopora*, *Botherophyllum*, and *Favosites* (corals); *Fenestella eumaciata* and *Loculipora* (bryozoans); *Actinopteria* and *Cypricardinia* (bivalves); *Platyceras* (gastropod); and the trilobites *Phacops* and *Greenops* (Savarese et al., 1986). Because of the diversity of fossil fauna at this site, the Centerfield limestone is interpreted as an aerobic depositional environment.

STOP 4: THE LOWER BLACK SHALES OF CAYUGA CREEK

The Stop 4 exposure at Cayuga Creek reflects a much different paleoenvironment from the previous sites. Towards the end of the Middle Devonian, the Appalachian Basin began to deepen in western New York. As a result, the type of submarine deposition changed from an aerobic to anoxic environment (Brett and Baird, 1994; Isachsen, 2000). The Windom Shale at this location is very dark gray to black colored and is thinly bedded. Narrow lenses of the Leicester Pyrite occur at the unconformable interface between the Windom Shale and the overlying Geneseo Shale (Figure 4). Like the Alden Pyrite, the Leicester Pyrite bed contains small brachiopods, bivalves, ammonoids, and trace fossils (Dick and Brett, 1986; Brett and Baird, 1994). The Geneseo Shale is the lowermost member of the Genesee Formation and represents an anoxic deepwater environment. A few thin layers of black shale with chonetid brachiopods likely represent brief environmental changes into dysoxic conditions. Also, the rounded concretions in this unit may have assemblages of conodonts and other microfossils, but overall the Genesee Black Shale is nonfossiliferous (Brett and Baird, 1994).

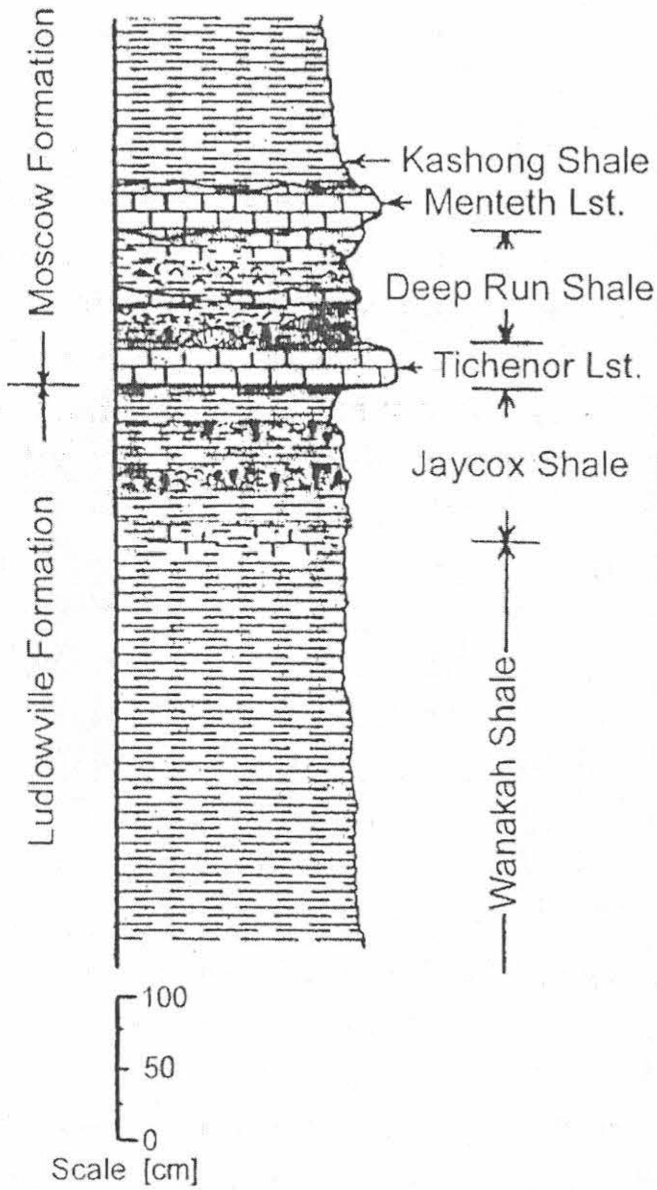


Figure 10. Partial Buffalo Creek stratigraphy. From Maletz, 2006.

STOP 5: THE LOWER WINDOM SHALE AT BUFFALO CREEK

Although deep water environments do not usually have the fossil diversity of shallow water environments, the abundance of fossils isn't necessarily affected. The lowest portion of the Windom Shale Member of the Moscow Formation represents submarine deposition in dysoxic conditions. Unlike the Alden and Leicester Pyrite beds, the lower Windom is not indicative of a highly sulfidic paleoenvironment. The maximum thickness of the Windom Shale is approximately 60 meters (200 feet), but in western New York its thickness is closer to 15 meters (50 feet). Shales and mudstones encompass most of the Windom, with a few thin bands of limestone and concretions scattered throughout (Brett and Baird, 1994). Since it is stratigraphically higher (and younger in age), the bottom of the Windom Shale outcrops upstream of the Tichenor and Menteth Limestones, with Kashong Shale (Figures 10 and 11).

The lower part of the Windom Shale consists of several unique beds. A phosphate bed exists along the bottom Windom contact with the Kashong Shale. This bed consists of a bioturbated gray mudstone with interbedded pebbles (Brett and Baird, 1994). The thin phosphate layer transitions into "soft medium gray" shale. This shale is identified by the presence of the common brachiopod *Ambocoelia umbonata*. Other abundant fossils from this bed include chonetid brachiopods (e.g. *Devonochonetes scitulus*), rugose corals, and the trilobite *Phacops rana*. At Buffalo Creek, the *Ambocoelia* beds can be used to identify the Lower Windom Shale and locate other adjacent sedimentary units (Figure 11; Baird and Brett, 1983; Brett and Baird, 1994).

SUMMARY

Depositional settings in western New York changed many times throughout the Middle Devonian. Sediment runoff from the eroding Acadian Mountains and variations in sea level were directly responsible for many of these changes. The Appalachian Basin deepened and shallowed, sediment supply changed, and the fossil assemblages shifted to accommodate these active processes. Each site on this trip was selected to give the participant multiple glimpses into the variation of the distant past. Through identifying fossils and understanding the conditions by which they were deposited, it should be possible for grade school students to reconstruct the paleoenvironment of the Hamilton Group.

ACKNOWLEDGEMENTS & NOTES

The authors would like to thank Dr. Richard S. Laub from the Buffalo Museum of Science for his assistance in identifying corals and other specimens from several of the sites on this trip. The authors also acknowledge Dr. Gordon C. Baird for his help with recognizing the Retsof locality and its position in the Kashong stratigraphy. Some components of this project were funded by the National Science Foundation through the Buffalo Geosciences Program at the University at Buffalo (www.bgp.buffalo.edu). Special thanks to Kristin A. Sturtevant for review of the text and figures, and to Kathryn M. Whalen for assistance in road logging. The authors credit Dr. Robert D. Jacobi from the University at Buffalo for his trip suggestions and subsequent guidance throughout the process of drafting this guide.

See the Appendix for images of some of the more common fossils on this trip. Figure 14 is a special fossil cartoon activity for children, designed by the Buffalo Geosciences Program.

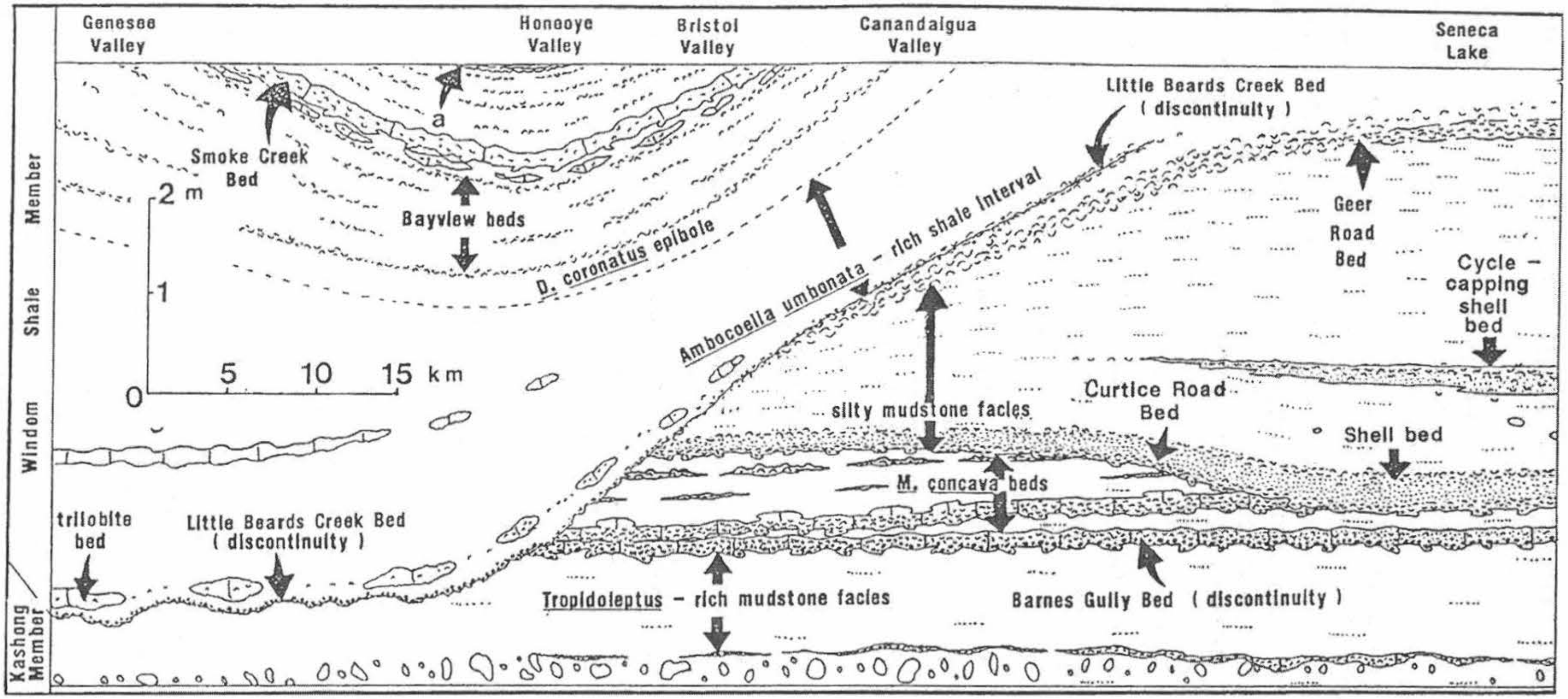


Figure 11. Regional deposits of the Late Middle Devonian. Of particular interest here is the "*Ambocoelia* umbonata - rich shale interval," or simply the "*Ambocoelia* beds" of the Lower Windom Shale. Modified from Brett and Baird, 1994.

APPENDIX

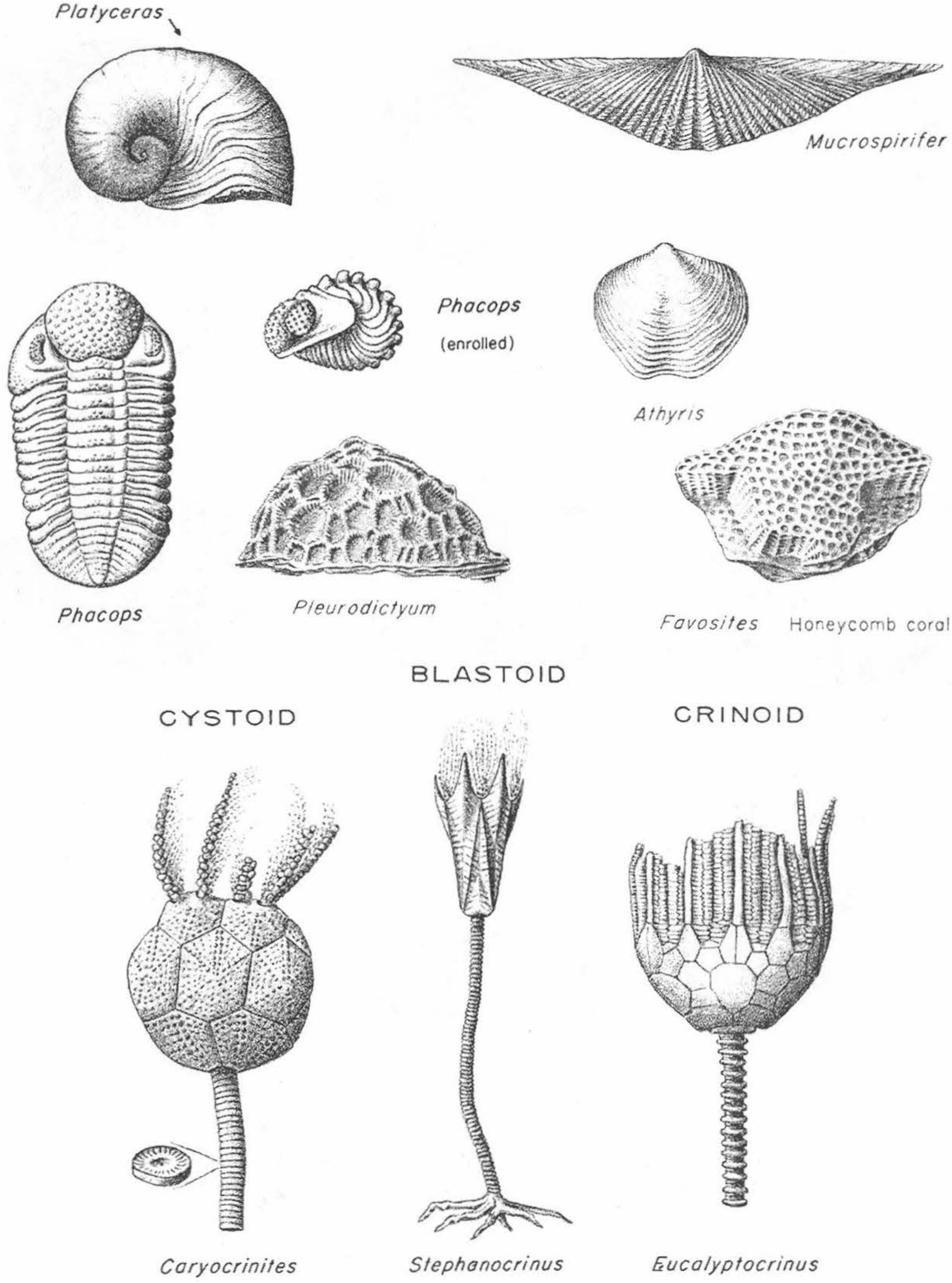
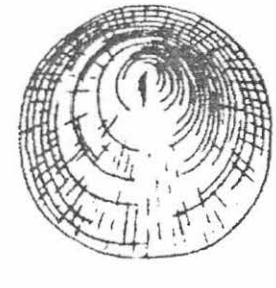


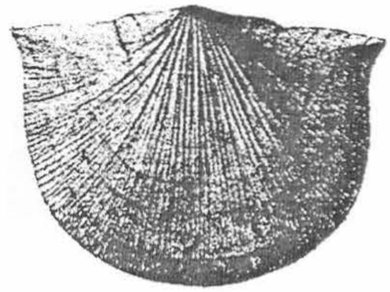
Figure 12. Miscellaneous fossils from trip localities. Modified from Isachsen et al., 2000.

COMMON DEVONIAN BRACHIOPODS

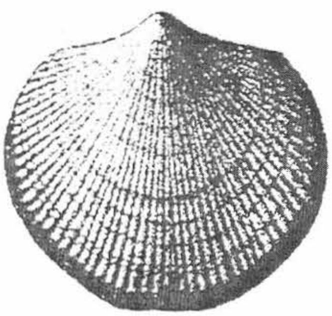


Orbiculiodea sp.

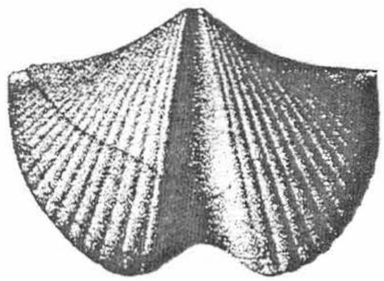
Rhipidomella sp.



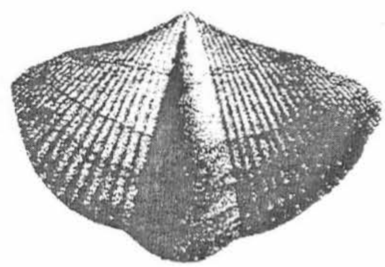
Stropheodonta demissa



Pseudoatrypa devonica



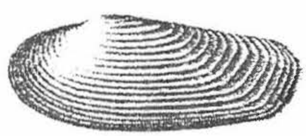
Spinocyrtia granulosa



Mediospirider auduculus

COMMON PELECYPODS (BIVALVES)

Pterinopecten sp.



Palaeoneilo sp.

Plethomytilus sp.

Figure 13. Common brachiopods and pelecypods (bivalves) from the Middle and Upper Devonian rocks found on this field trip. These fossils are particularly abundant in the Wanakah and Windom Shales, and will be typically found at Stops 5 and 6. Based on figures in Bastedo, 1999 and from original drawings by Grabau, 1898-99.

Add your own words to this zany scene from the Paleozoic!

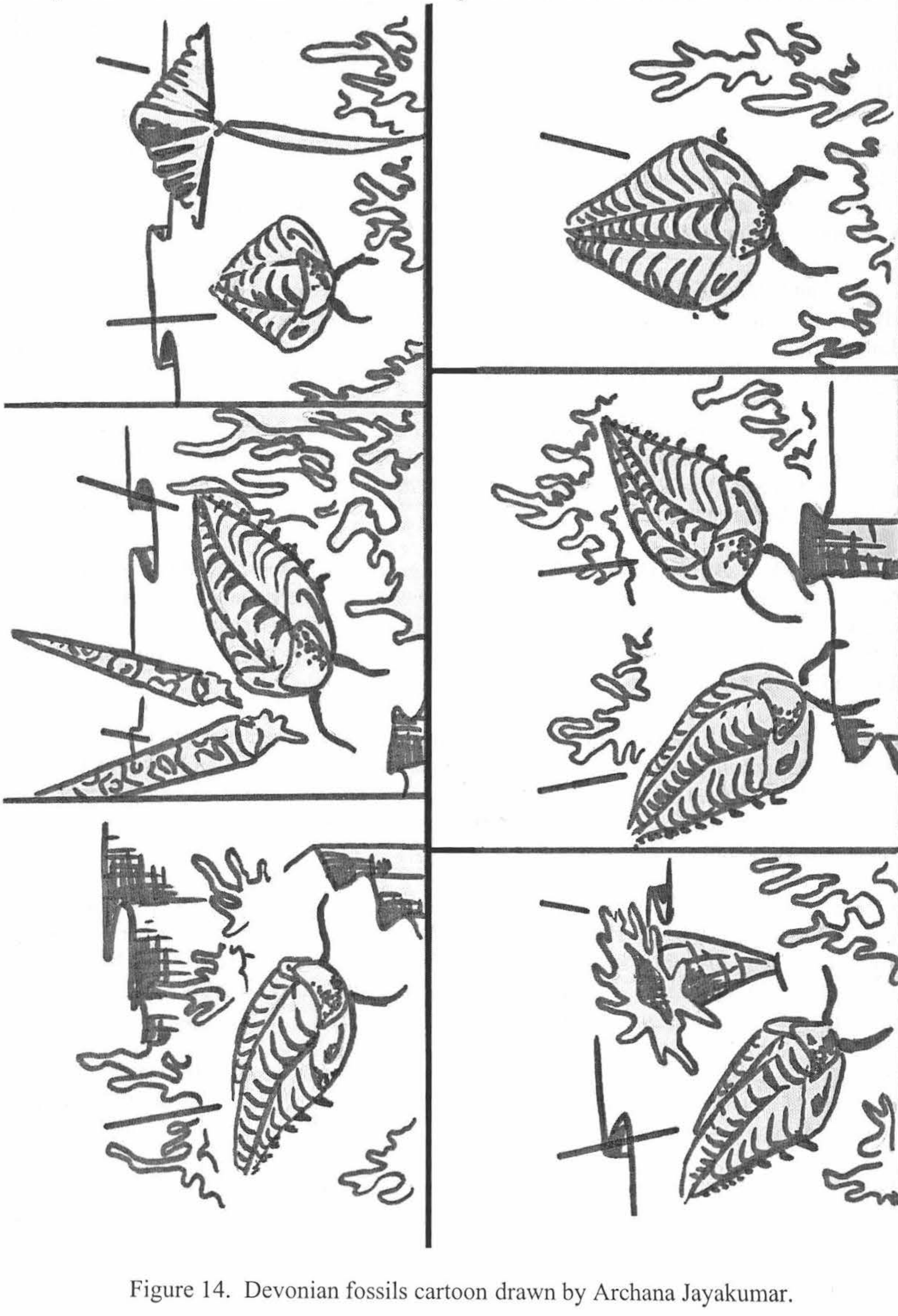


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Figure 14. Devonian fossils cartoon drawn by Archana Jayakumar.

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FIELD TRIP ROADLOG

Total	Distance	Directions	Location
0.0	0.0	Head East on Church St. toward Lower Terrace St.	Adam's Mark Hotel, 120 Church St., Buffalo, NY
0.2	0.2	Church St. becomes S. Division St.	S. Division St.
0.4	0.2	Left onto Elm St./NY-33 E	NY-33 E
8.0	7.6	Exit I-290 toward I-90 E/Albany	I-290/I-90 E
39.6	31.6	Take exit 48 (Rt. 98) toward Batavia	Onramp for I-90 E
40.1	0.5	Left onto NY-98 S	Intersection after tollbooth
41.2	1.1	Left onto W Main St./NY-33/ NY-5/NY-63 S	City of Batavia
41.5	0.3	Right onto NY-63 S (Rt. 63)	City of Batavia
53.3	11.8		Town of Pavilion
58.8	5.5		Town of York
62.2	3.4	Left into parking lot near Bank of Castile/Dollar General, **STOP 1**	Off Rt. 63 near intersection of Rt. 63 and Retsof Rd.(Greigsville)

STOP 1. Retsof Locality (of older literature). Cross Rt. 63 at the entrance to the parking lot. Proceed down the gravel trail (westward) towards and just beyond the Rt. 63 Retsof Switch Structure. Head south about 250-300 meters until the flat bedding surface turns into outcrop near old railroad yard. If vegetation is high, it may be difficult to find the trail. The best collecting from this site is found along the bluff wall adjacent to the rail yard, although surface collecting is also possible in some places.

Geologic unit: Kashong Shale Member of the Moscow Formation, Hamilton Group
Geologic age: Middle Devonian
Common fossils: Crinoids, brachiopods, corals, bryozoans

Total	Distance	Directions	Location
62.2	0.0	Right out of parking lot	Rt. 63
71.5	9.3		Drumlin-like landform
79.1	7.6	Left onto Bethany Center Rd.	Intersection of Rt. 63 and Bethany Center Rd., Town of East Bethany
81.2	2.1	Park on gravel shoulder on right	Bethany Center Rd. near shale/mud pit approx. 0.4 mi past Paul Rd.

STOP 2. Alden Pyrite Beds (east-facing shale pit on Bethany Center Road). Exit vehicle and walk approximately 150 meters west into the clayey hills to the right (west) of the road. Pyrite beds outcrop from the weathered bedrock surfaces near recently incised channels throughout the site. Calcareous concretions eroding from the outcrop often contain brachiopods and cephalopods. Pyritized fossils also appear on muddy flats below weathered outcrop.

Geologic unit: Ledyard Shale Member of the Ludlowville Formation, Hamilton Group
Geologic age: Middle Devonian
Common fossils: Pyritized brachiopods, trilobites, rugose corals, cephalopods, gastropods

STOP 3. Delaware, Lackawanna, and Western Railroad Tracks. From Stop 2, head back to the road and walk north about 200 meters, past the guard rails on Bethany Center Rd. and descend left (west) on gravel path into the railroad bed. Abundant fossils can be found both on the surface and in weathered bedrock fragments. Possible lunch stop.

Geologic unit: Centerfield Limestone Member of the Ludlowville Formation, Hamilton Group
Geologic age: Middle Devonian
Common fossils: Rugose and tabulate corals, bryozoans, brachiopods, trilobites, crinoids

Total	Distance	Directions	Location
81.2	0.0	Continue south	Bethany Center Rd.
83.0	1.8	Right onto Rt. 63 S toward	Intersection of Bethany Center Rd. and Rt. 20 W connection road
83.1	0.1	Right onto Rt. 20 W toward Darien Center	Intersection of Rt. 20 connection/ Old Telephone Rd. and Rt. 20
89.4	6.3		Village of Alexander

94.2	4.8		Town of Darien
96.4	2.2	Left onto Rt. 77 S toward Bennington	Intersection of Rt. 20 and Rt. 77 Welcome to Darien Center!
100.9	4.5	Right onto Rt. 354 W	Intersection of Rt. 77 and Rt. 354
101.0	0.1	Right onto Rt. 354 W/Clinton St.	Town of Bennington
104.7	3.7		Cowlesville, NY
105.2	0.5		Town of Marilla
107.0	1.8	Left onto Eastwood Rd, park on right shoulder, **STOP 4**	Intersection of Rt. 354/Clinton St. and Eastwood Rd., Marilla

STOP 4. Cayuga Creek. Cross Eastwood Rd. and descend to the creek via the dirt trail alongside the overpass. Take note of the bedrock on which the overpass trusses are built. The black shales of the lower Geneseo are nearly void of fossils at this location except for sporadic pavements of chonetid brachiopods. Lenses of the Leicester Pyrite contain pyritized burrows and fossil steinkerns.

Geologic units: Windom Shale Member, Moscow Formation, Hamilton Group; Leicester Pyrite (in lenses along unconformity), Genesee Formation; and Geneseo Shale Member, Genesee Formation.
Geologic age: Middle and Upper Devonian
Common fossils: No common fossils, sparse brachiopods

Total	Distance	Directions	Location
107.0	0.0	Turn around and head North	Eastwood Rd. near Cayuga Creek
107.0	0.0	Left onto Rt. 354/Clinton St.	Intersection of Eastwood Rd. and Rt. 354/Clinton St.
109.6	2.6	Left onto Two Rod Rd.	Intersection of Rt. 354/Clinton St. and Two Rod Rd.
110.6	1.0	Right onto Bullis Rd.	Intersection of Two Rod Rd. and Bullis Rd., Town of Marilla
112.8	2.2	Left onto Buffalo Creek Bridge Ramp (Between Stolle Rd. and Girdle Rd.), **STOP 5**	Intersection of Bullis Rd. and Buffalo Creek Bridge ramp

STOP 5. Buffalo Creek. After parking, descend down ramp trail and cross old Buffalo Creek bridge. Proceed down one of several trails to the creek. Approximately 300-400 meters downstream from the bridge, cross the creek in a shallow place to get access to the vast exposures of bedrock. The Lower Windom Shale is particularly accessible on the north bank of the creek upstream of the old Bullis Rd. bridge.

Geologic units: Wanakah Shale and Jaycox Shale Members, Ludlowville Formation, Hamilton Group; Tichenor Limestone, Deep Run Shale Member, Meneth Limestone, Kashong Shale Member, and Windom Shale Member, Moscow Formation, Hamilton Group; and Geneseo Shale, Genesee Formation.
Geologic age: Middle and Upper Devonian
Common fossils: Trilobites, brachiopods, corals, bryozoans

PENN DIXIE (OPTIONAL STOP)

Total	Distance	Directions	Location
112.8	0.0	Turn around, left onto Bullis Rd.	Intersection of Buffalo Creek Bridge ramp and Bullis Rd.
117.8	5.0	Left onto Transit Rd./Rt. 78 S	Intersection of Bullis Rd. and Transit Rd./Rt. 78
117.9	0.1	Right onto Rt. 400 N	Onramp for Rt. 400 N
122.7	4.8	Exit Rt. 400 to I-90 W	Onramp for I-90 W
124.7	2.0	Take exit 56 toward Blasdell	I-90 W
125.2	0.5	Right onto Rt. 179 W/Milestrip Rd.	Intersection after tollbooth
125.4	0.2	Left onto Rt. 62/South Park Ave.	Intersection of Rt. 179/Milestrip Rd. and Rt. 62/South Park Ave.
126.5	1.1	Right (west) onto Big Tree Rd.	Intersection of Big Tree Rd. and Rt. 62/South Park Ave.
126.8	0.3	Right onto Bristol Rd.	Intersection of Bristol Rd. and South Park Ave., Hamburg
127.0	0.2	Left onto North St.	Intersection of North St. and Bristol Rd.
127.2	0.2	Park on entrance road, **STOP 6**	Penn Dixie Paleontological and Outdoor Education Center

STOP 6. Penn Dixie Fossil Quarry. The ridge to the south of the site is composed of the North Evans and Genundewa Limestones. Windom Shale comprises the bulk of the mud flats. Tichenor Limestone caps the small drainage to the northeast of the site, and Wanakah Shale lines the banks of the stream and the adjacent Fall Brook. For more information on the localities, see the Penn Dixie field trip in this guide.

Geologic units: Wanakah Shale Member, Ludlowville Formation, Hamilton Group; Tichenor Limestone and Windom Shale Member, Moscow Formation, Hamilton Group; North Evans and Genundewa Limestones, Genesee Formation.
Geologic age: Middle and Upper Devonian
Common fossils: Brachiopods, trilobites, corals, crinoids, bryozoans, cephalopods, fish bones

RETURN TO BUFFALO (FROM STOP 5)

Total	Distance	Directions	Location
112.8	0.0	Turn around, left onto Bullis Rd.	Intersection of Buffalo Creek Bridge ramp and Bullis Rd.
117.8	5.0	Left onto Transit Rd./Rt. 78 S	Intersection of Bullis Rd. and Transit Rd./Rt. 78
117.9	0.1	Right onto Rt. 400 N	Onramp for Rt. 400 N
122.7	4.8	Exit Rt. 400 to I-90 E	Onramp for I-90 E

Continue to 33 West (Downtown) or I-290