PALEOENVIRONMENTAL ANALYSIS OF THE FIDDLERS GREEN FORMATION (LATE SILURIAN) IN NEW YORK STATE

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INTRODUCTION

The Late Silurian of New York has long been famous for its eurypterid fauna. A number of investigators have dealt with the occurrence of these unique arthropods such as Clarke and Ruedemann (1912), Ruedemann (1916), Kjellesvig-Waering (1958, 1963, 1964), and Ciurca (1973, 1975, 1978, 1982, 1986). An attempt to determine the habitat of the eurypterids by analyzing their geologic distribution was done by O'Connell (1913, 1916).

Recent works that have helped to refine the stratigraphy are those of Fisher (1960), and Rickard (1962, 1969, 1975). Within the last 15 years more attention has been directed toward the interpretation of environments of deposition. Treesh (1972), Ciurca (1973, 1978, 1982, 1986), Belak (1980), Hamell (1981, 1985, 1986), and Tollerton and Muskatt (1984) have proposed a number of paleoenvironmental models for the Late Silurian rocks of New York.

STRATIGRAPHY

The Late Silurian of New York have been generally described as a transgressive sequence. Examination of lithologies within the Bertie Group, however, indicates multiple oscillations of the Late Cayugan Sea. Lithofacies were deposited in elongate east-west belts arrayed subparallel to the present day outcrop belt. Following Walther's law, the vertical sequence of these facies is inferred to represent lateral north-south shifts of successive environmental belts. The result is a complex package of rocks representing sabkhal to subtidal deposition of carbonate sediments. Several lithofacies are traceable from eastern Ontario, Canada to Cedarville in eastern New York, a distance of approximately 250 miles.

The Bertie Group consists of five formations. In ascending order they are the Fort Hill, Oatka, Fiddlers Green, Scajaquada-Forge Hollow and the Williamsville. Recent terminology for the Bertie Group is shown in Figure 1. In the Syracuse region the Bertie Group has a maximum thickness of 90-100 feet and thins to about 50 feet to the east and west. The increased thickness in central New York is largely due to the occurrence of the gypsum beds of the Forge Hollow Formation. The interval roughly corresponds to the thinner Scajaquada Formation of western New York. Eastward, the entire Bertie Group grades into the gray to green pyritic shales of the Brayman Formation. Late Silurian rocks in western New York are shown in Figure 2.

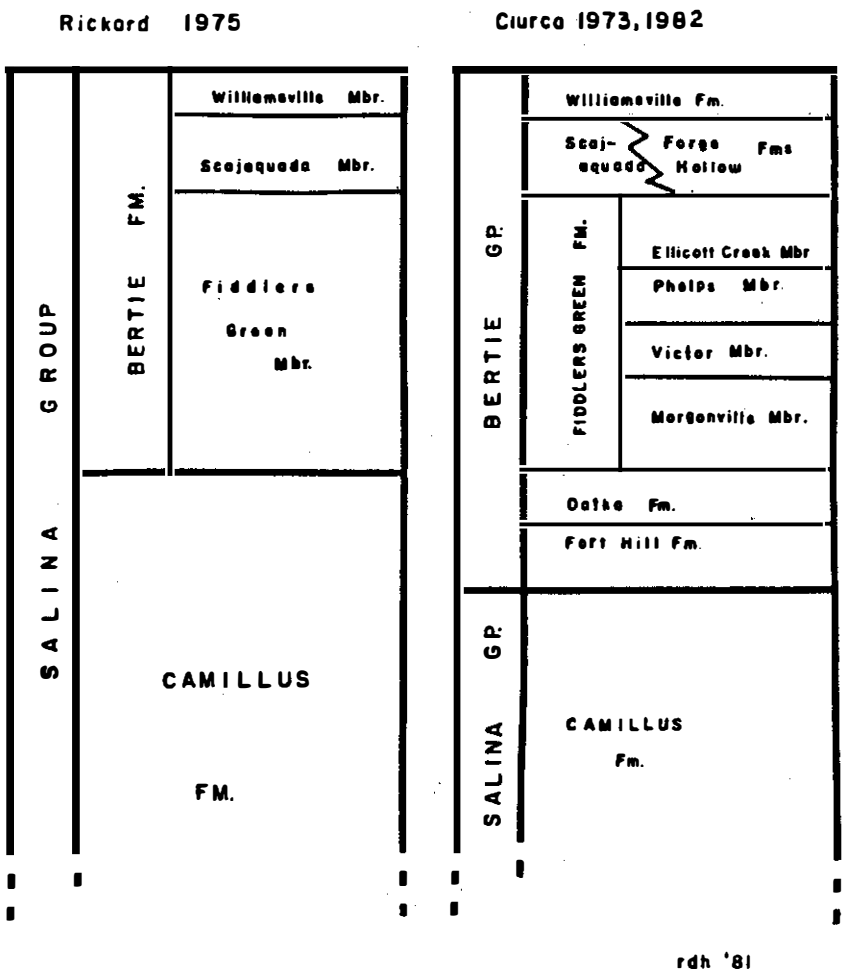


FIGURE 1. Stratigraphic terminology for part of the Late Silurian sequence in New York State.

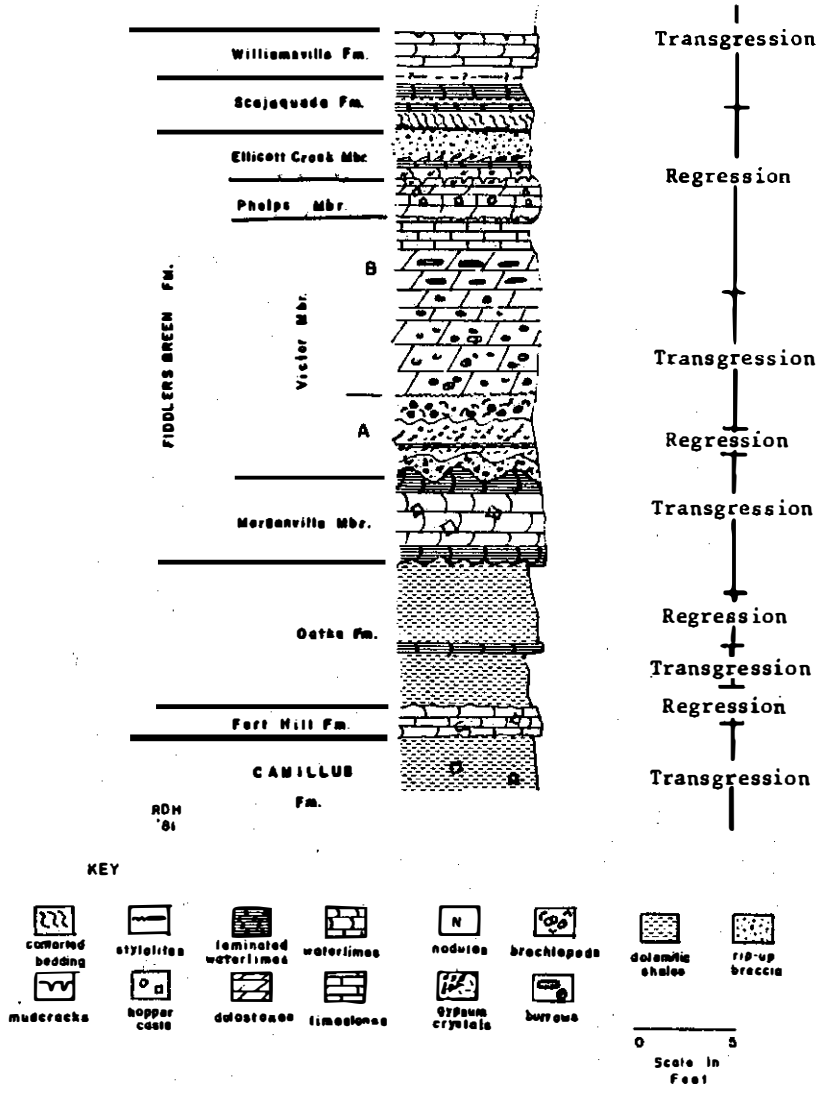


FIGURE 2. Generalized stratigraphic column for western New York State.

FORT HILL FORMATION

The basal one to two feet of the Bertie Group is the Fort Hill Formation. It overlies dolomitic shales of the Camillus Fm. (Salina Gp.) and is a very fine-grained, straticulate dolostone, characterized by small mineraliferous vugs of calcite, large salt hoppers, ostracods, and eurypterid fragments (Ciurca, 1973; p. D-3). The Fort Hill Waterlime is well developed in western New York, but has not been found east of Phelps.

Oatka Formation

The overlying Oatka Formation is about 10 feet thick in central-western New York. These dolomitic shales are easily fragmented into blocky chips having a silty texture. No fossils have been reported from this unit and the lithology represents a recurrence of Camillus-type deposition. Like the Fort Hill Waterlime, the Oatka Fm. is unknown east of Phelps and the interval may be represented by gypsum deposits that underlie the Fiddlers Green Formation in central New York.

Fiddlers Green Formation

The Fiddlers Green Fm. is divided into four members. In ascending order they are the Morganville Waterlime, the Victor Member (dolostones/ limestones), the Phelps Waterlime and the Ellicott Creek Breccia. The formation is about 25 feet thick throughout its outcrop belt which extends from the Niagara Peninsula in Ontario, Canada east to Passage Gulf in eastern New York.

Morganville Waterlime Formation

The Morganville Waterlime, the lowest member of the Fiddlers Green Formation, is approximately five feet thick throughout central-western New York. The contact with the underlying Oatka Formation is sharp. The basal Morganville Waterlime is finely laminated and grades upward to a vaguely cross-laminated, thicker bedded, less straticulate dolostone that is typical of this unit. These features can be seen at the roadcuts along N.Y. Route 88 and the adjacent New York State Thruway, both north of Phelps (Stop 1). This locality is the reference section for the Fiddlers Green Formation in western New York.

Fossils are rare in the Morganville Waterlime; only fragmentary remains of *Eurypterus* have been reported from this unit at Marcellus Falls and Cayuga Junction (Ciurca, 1973, 1978). Salt hopper casts and the ostracod *Leperditia* have been found at Cayuga Junction and at other localities. The contact with the overlying Victor Mbr. is disconformable being marked by an undulatory surface (Fig. 3). This feature is well-displayed along the roadcuts on the New York Thruway and N.Y. Route 88.

FIGURE 3. Morganville Waterlime (massive unit) overlain by the Victor A Submember of the Fiddlers Green Formation. Note the Aglal (thrombolite?) structure left of the meter stick and the channel. Truncated surface marks the contact of the units.

Victor Member

The Victor Member extends from 2 miles west of Hagersville, in Ontario, Canada east acoss New York State to Passage Gulf near Cedarville. This unit is a 20 foot sequence of dolostones with some local limestone layers or lenses. The dolostones are coarser grained, usually mottled, possess mineraliferous vugs (Fig. 4), and low diversity fauna consisting of brachiopods (Whitfieldella) and ostracods (Leperditia). Eurypterid remains are rare and have been found only at Morganville and Passage Gulf. The upper portion of the Victor B Submember at Passage Gulf has yielded fragments of Eurypterus and Pterygotus along with gastropods and the inarticulate brachiopods Lingula. The eurypterid fauna of the Victor Member at Passage Gulf is not as rich as the overlying Phelps Waterlime Member. The limestones of the lower Victor A Submember along Route 88 have produced the conodont Spathognathodus remscheidensis remscheidensis, which is correlated with the eosteinhornesis Zone of Europe (Rickard, 1975). Barnett (1971) has suggested that S. remscheidensis ssp. may prove useful for intrabasinal correlation in the Appalachian Basin.

The basal contact of the Victor A Submember with the underlying Morganville is irregular. Cryptalgal structures have been observed drapped over the elevated portions of the Morganville (Fig. 3). Burrows and intraclasts are common. This zone is less than one foot thick and grades upward into a 3 foot sequence of sublithographic limestones with abundant lath-shaped gypsum crystals (Fig. 5) up to 5 mm. in length (Hamell, 1981; p. 17). A concentration of these evaporites occurs in the central portion of the Victor A Submember. Upward the gypsum crystals are localized in wisp-shaped lenses together with disarticulated brachiopod shell fragments.

A slight undulatory surface marks the upper contact with the overlying Victor B Submember. This unit is characterized by lithologies, fauna, and sedimentary structures associated with non-restricted subtidal deposition. The basal 1.5 feet is a brachiopod-rich shell hash layer that is highly bioturbated and capped by a well-developed stylolitic horizon. The overlying 11 feet consist of limestone and dolostone beds that are dominated by the brachiopod Whitfieldella. Horizontal burrows are common in the top portion of this unit. A recurrence of Victor A lithology marks the uppermost 2.5 feet of Victor B and a pronounced stylolitic seam marks the contact with the overlying Phelps Member. The aforementioned lithologiies of the Victor submembers occur primarily in the centrally located exposures, i.e. the Phelps to Cayuga Lake region.

Phelps Waterlime Member

The Phelps Waterlime Member is fairly uniform in thickness, usually 5 feet, except where truncated by the pre-Onondaga unconformity. It is a very fine-grained, locally straticulate dolostone that exhibits good conchoidal fracture. The top of the Phelps is marked by a mud-cracked horizon that can be traced from central New York (Phelps) to the easternmost locality at Deck (Ciurca, 1978). West of Phelps the mud-cracked horizon is not present. It is either absent due to erosion or is represented only a few inches of waterlime beneath the Ellicott Creek Breccia Member.

FIGURE 4. Mineralized vug in the upper part of Victor A (limestone). Vug diameter about 6 inches.

FIGURE 5. Small crystal molds (gypsum) in lower part of Victor A (limestone). Crystal molds about 0.5 cm. in length.

It is the Phelps Waterlime that has yielded the remarkable eurypterid fauna known as "The Herkimer Pool" for which the Herkimer County area has long been famous. In addition to three genera of eurypterids, the Phelps Waterlime has yielded at least three species of scorpions (Kjellesvig-Waering, 1986) and the aquatic vascular land plant Cooksonia. The latter two forms are found only at the easternmost exposures.

Sedimentary structures such as salt hoppers and salt-reticulate casts characterize the Phelps member, particularly in western-central New York. Specimens 8 inches on a side have been found at the Nied Road Quarry near LeRoy in western New York. To date only a single salt hopper has been reported from the Phelps Waterlime at Passage Gulf. Small scale cross-bedding has been observed at this locality as well as windrows of fossil fragments and complete eurypterid specimens. The Phelps Waterlime at the type section is shown in Figure 6.

Ellicott Creek Waterlime Member

The Ellicott Creek Waterlime is thickest (6-8 ft.) in the Niagara Peninsula of Ontario, Canada, and thins (1-2 ft.) eastward to Phelps, New York (Ciurca and Gartland, 1975, 1976). This unit contains an eurypterid fauna that is similar to the Phelps Waterlime eurypterid assemblage (Ciurca, 1982; p. 114). Chert and sphalerite nodules are found in the lower portion, overlying the mud-crack zone of the phelps Member. Above this horizon laminae grade from contorted bedding to a zone of rip-up clasts suspended in a micrite matrix. The clasts are tabular to subrounded in shape and weather to a light buff color. Within this zone, sand-sized silica grains occur. Petrographic analysis suggests the intraclasts are partially silicified oolites and the mineralized nodules are replacements of evaporites (Hamell, 1981; p. 22). The contact with the overlying Scajaquada Formation is gradational.

Scajaquada-Forge Hollow Formations

The Forge Hollow Formation consists of approximately 60 feet of gypsum-bearing dolostones in the Syracuse area but thins eastward to about 30 feet near the town of Deck. No fossils have been reported from this interval. The Scajaquada Formation of western New York, usually less than 15 feet in thickness, grades eastwward into the Forge Hollow Formation in the Auburn area.

Williamsville Formation

The Williamsville Formation of western New York is characterized by the presence of an Eurypterus fauna (Eurypterus remipes lacustris). Other fossils commmonly encountered are the phyllocarid Ceratiocaris, the inarticulate brachiopod Lingula and the graptolite(?) Inocaulis. Cephalopods and gastropods are present but poorly preserved. In central New York the Euryterus fauna, which is characteristic of western New York, is replaced by a Paracarcinosoma (formerly Eusarcus) fauna as reported by Ciurca (1978, 1982). East of Syracuse this interval is marked by a thin petroliferous waterlime that is unfossiliferous.

FIGURE 6. Upper Victor B Submember (flaggy beds) and Lower Phelps Waterlime Member. Contact just below the meter stick.

Throughout western New York the Williamsville contact with the overlying Cobleskill Formation is gradational. At Forge Hollow the contact is disconformable (Rickard, 1962). The Williamsville Formation grades eastward into the uppermost Brayman Formation.

PALEOENVIRONMENTAL INTERPRETATION

Based upon the geographic and vertical distribution of lithologies, sedimentary structures, petrographic and paleontological observations, eight depositional environments are inferred by comparison with modern depositional environments (Persian Gulf and elsewhere):

1. sabkha
2. lower supratidal
3. upper intertidal to lower intertidal
4. lower intertidal
5. restricted subtidal
6. non-restricted subtidal
7. hypersaline lake
8. semi-restricted lagoon-estuary

The environmental distribution of facies for a portion of Fiddlers Green time is shown in Figure 7. The paralic arrangement of Bertie Group facies is illustrated in Figure 8.

Sabkha

Sabkhal sedimentation is characterized by dolomitic muds and an absence of organisms. During dolomitization shells are usually leached out during flooding. Relict evaporite minerals such as gypsum-anhydrite and halite are generally preserved in sabkha-type sediments. Later diagenesis can replace the evaporite nodules with silica and/or other minerals. The Oatka and Scajaquada Formations are interpreted as representing sabhkal deposition as is the underlying Camillus Formation of the Salina Group.

Hypersaline Lakes

The environmental setting for the deposition of the Forge Hollow gypsum beds is analogous to present day sedimentation of gypsum occurring in shallow hypersaline lakes on Bonaire, in the Northern Antillies as reported by Lucia (1968). These restricted sabkhal-hypersaline lake deposits are completely separated from the ocean by a barrier composed of permeable sabkhal sediments. Precipitation of gypsum is maintained by a continuous influx of seawater through the permeable sediments. The deposits are bedded or laminated and form a thick sequence of evaporites. No organisms have been found associated with these lakes. The thick gypsum beds of the Forge Hollow indicate deposition in a restricted sabkhal-hypersaline lake.

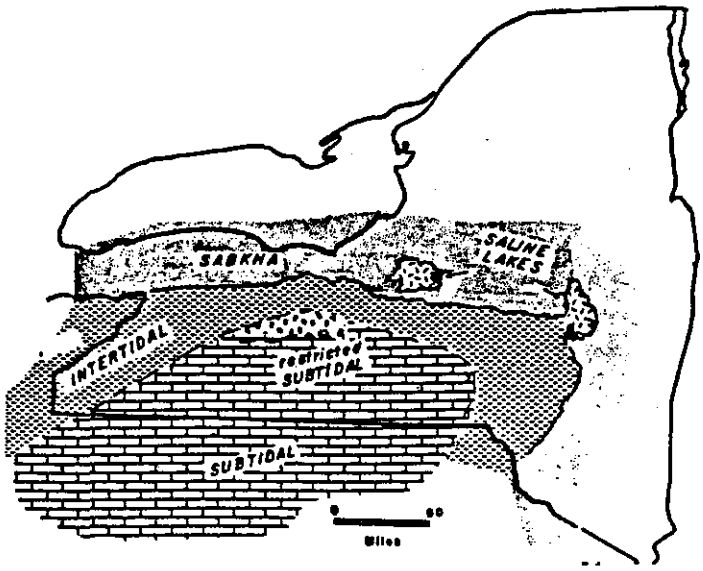


FIGURE 7. Paralic relationship of depositional environments during Fiddlers Green time. (From Hamell, 1981)

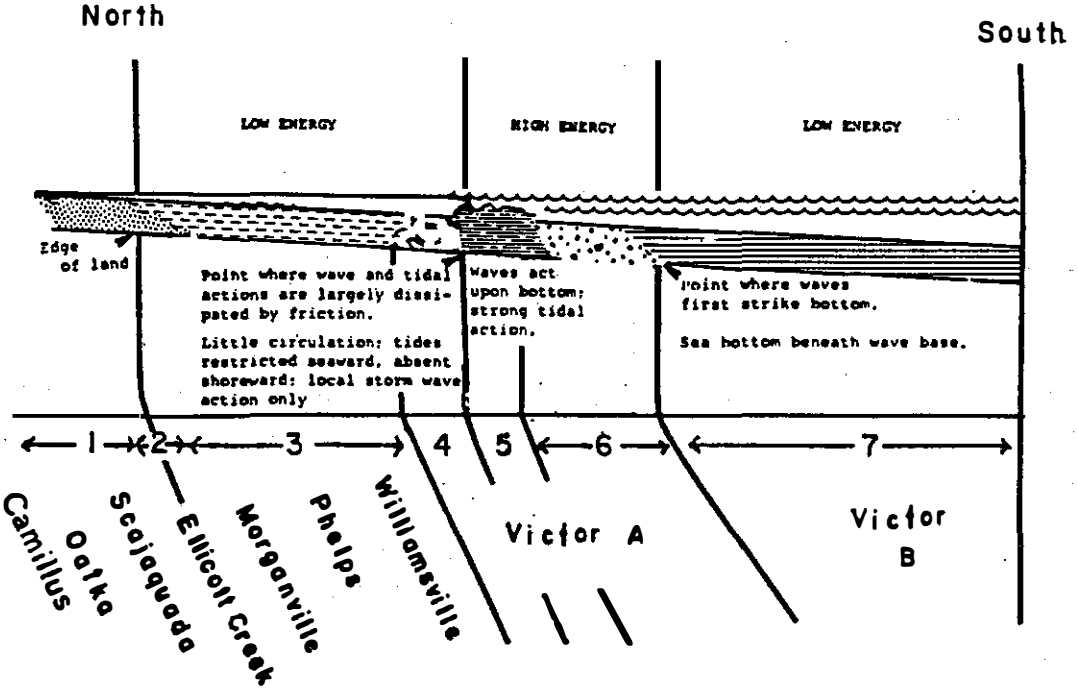


FIGURE 8. Cross section of Late Cayugan lithofacies indicating distribution of Bertie Group lithologies in accordance with Shaw-Irwin model of epeiric sea sedimentation and observations: 1) sabkha, 2) supratidal to intertidal (rip-up breccia), 3) intertidal, 4) restricted subtidal, 5) algal structures on eroded intertidal facies, 6) more normal marine subtidal, above wave base and 7) subtidal, below wave base (From Hamell, 1981).

Supratidal

The collapse and rip-up breccias of the Ellicott Creek Member (Fiddlers Green Fm.) were probably formed in the lower sabkhal to upper supratidal environments. This zone lies above the mean high tide and sedimentation occurs during excessively high spring tides or major storms. In the interim, the environment is subjected to long periods of subaerial exposure and evaporation. Collapse breccias are the result of dissolution of evaporite minerals and subsequent collapse of the sediment during periods of flooding.

Intertidal

Treesh (1972) and Belak (1980) have implied that the Brayman Shale, Phelps and Williamsville Waterlimes were deposited in an intertidal environment. Their environmental interpretation of these rock units does not provide an adequate explanation for the high pyrite content of the Brayman, which is lacking in the Phelps and Williamsville. Therefore, the Brayman represents a different environmental setting. As noted by Fisher (1960), the slight dissimilarity of the Brayman with the Forge Hollow Formations is due to a slight facies change. The stratigraphic relationship of these two rock units indicates a similar environment of deposition. However, in the case of the Brayman Shale, gypsum must have been inhibited from precipitating or accumulating. Furthermore, the deposition of black organic rich mud was favored in the Brayman environment for there is a lack of signigicant pyrite in the Forge Hollow gypsum beds. Morris and Dickey (1957) described modern evaporite deposition associated with black muds occurring in a relict river channel in Peru which forms an estuary with an open connection to the Pacific Ocean. Sulfate-reducing bacteria inhibit the accumulation of gypsum in this environment. Based on these lithological similarities, such an environmental setting can be postulated for the deposition of the Brayman Shale Formation.

Intertidal sedimentation is represented by portions of the Fort Hill Formation, the Morganville and Phelps Members of the Fiddlers Green Formation as well as the Williamsville Formation. This environment is characterized by mud-cracks that mark the upward transition into a supratidal environment. Hypersaline conditions are supported by the presence of salt hoppers, reticulate halite structures and laminated sediments. Cryptalgal structures and an eurypterid fauna are the main fossil constituents.

Subtidal

The lithographic limestone in the basal Victor A Submember contains the brachiopod Whitfieldella. Conditions of hypersalinity are indicated by a one foot thick bed of packed gypsum crystals in the central portion of Victor A and in the upper 2.5 feet of the Victor B Submember. These lithologies are indicative of deposition in a restricted upper subtidal environment.

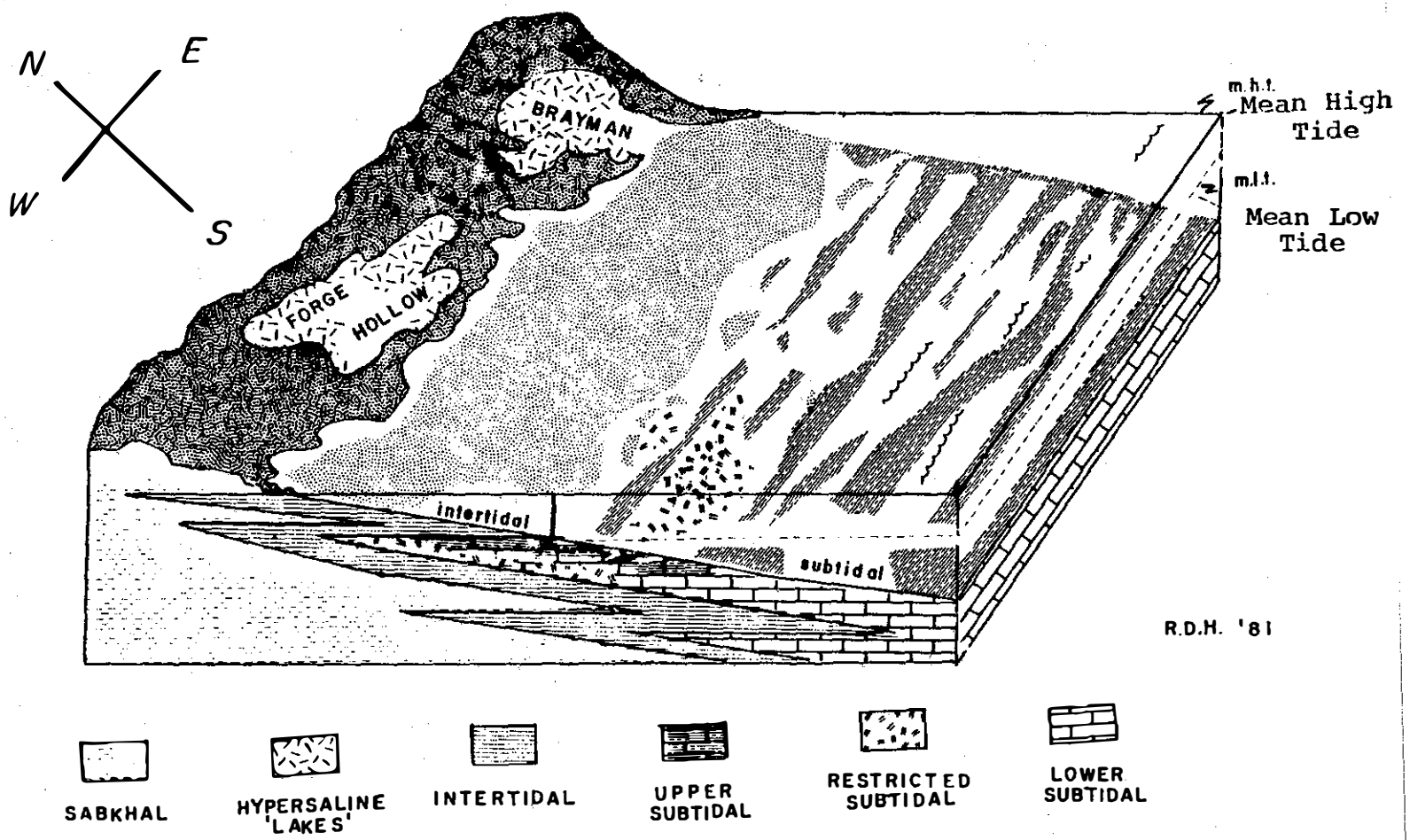


FIGURE 9. Schematic reconstruction of the environment and deposition of the Bertie Group lithologies.

The primary features of the Victor B Submember are the wavy-laminated to mottled and thick-bedded dolostones having a strong petroliferous odor. The mottled nature of this facies is due to bioturbation and is typical of modern shallow subtidal zones. Complete specimens of Whitfieldella and Leperditia are common. The deeper subtidal facies of the Victor B Submember is recognized by well-developed horizontal burrows. Although this environment represents a more offshore setting, the small size of Whitfieldella, low faunal diversity and the absence of typical marine organisms, are suggestive of less than normal marine conditions.

CYCLICITY AND DEPOSITIONAL HISTORY

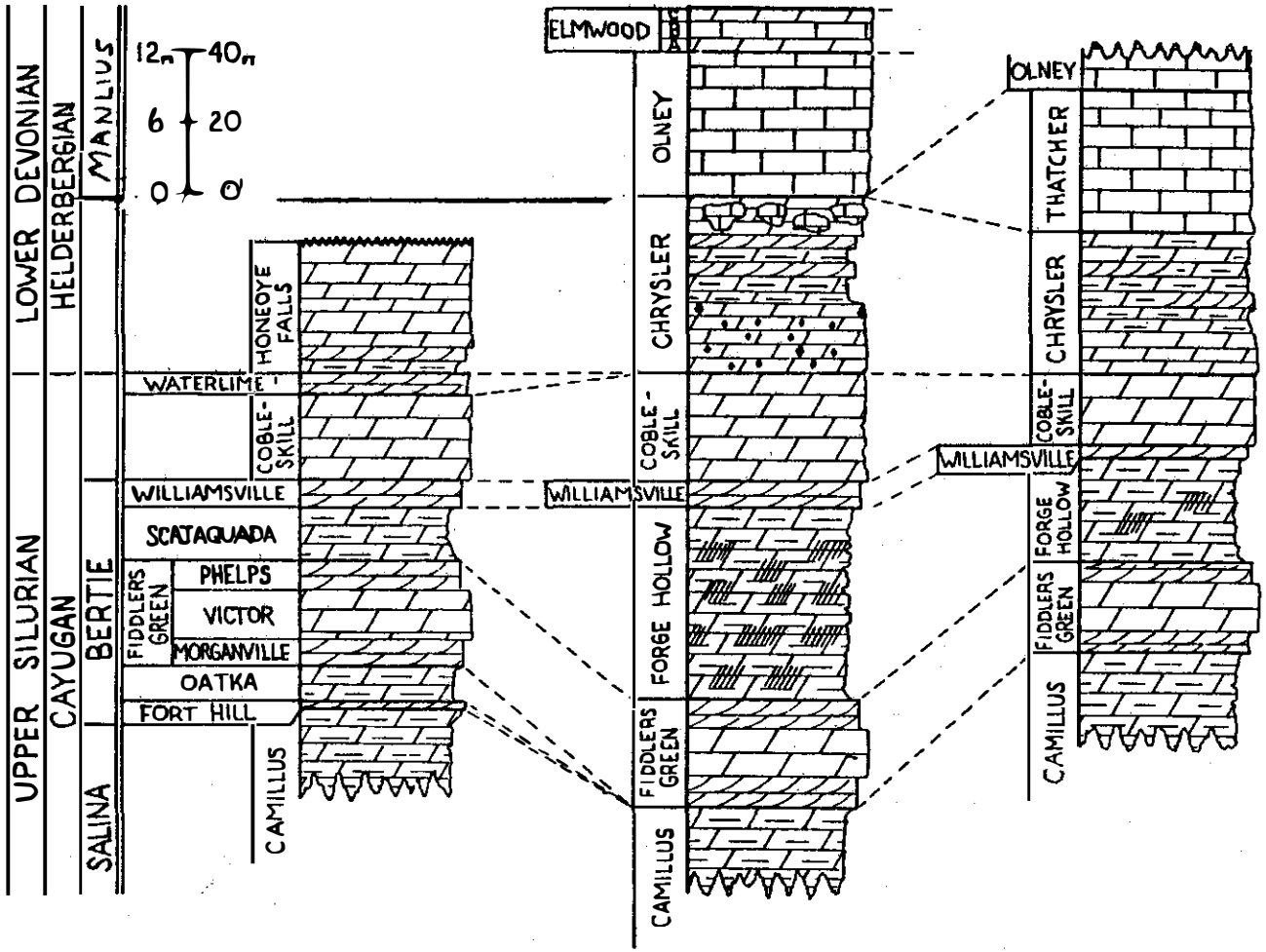
The cyclic nature of the Late Silurian strata in New York was indicated by Ciurca (1978). During deposition of the Bertie Group most of the lithofacies and biofacies were shifted geographically over a broad area. The waterlime facies, for example, disappears from a localized section only to recur repetitively at stratigraphically higher intervals. Concomitantly, the eurypterid faunas that are so well known from this facies also recur but are replaced by newly evolved or introduced species (Table 1).

The cyclic alternation of lithofacies and biofacies reflects the effects of salinity and sedimentation. Waterlimes formed mostly under hypersaline conditions but it is obvious that the thin limestones (Victor A Submember) were deposited in more nearly normal marine conditions. No normal marine limestones like those of the Cobleskill Formation (Stops 2, 3 and 7) are known in the outcropping of the Fiddlers Green Formation. Perhaps subsurface analysis of the Fiddlers Green Fm. is needed, especially to show how this formation merges with basinward deposits.

Whatever the underlying causes were for the repeated transgressions of the latest Silurian and Early Devonian, the stratigraphic column (Fig. 9) reflects the widespread shifting of shore to shallow restricted areas (sabkhal to intertidal) with the more offshore regimes of varying salinities (restricted to non-restricted subtidal).

TABLE 1

LITHOLOGY		FORMATION or MEMBER	FAUNA
shaly dolostone		Scajaquada Formation	barren
waterlime	Fiddlers Green Formation	Phelps Waterlime	eurypterids
crystalline dolostone & limestone		Victor Member	brachiopods, ostracods
waterlime		Morganville Waterlime	eurypterids
shaly dolostone		Oatka Formation	barren



Stratigraphic sections for Syracuse area (center column) and comparable sections to west, south of Rochester (left column), and to east in Stockbridge Valley area (right column).

FIGURE 10 (modified from Ciurca, 1978)

After two major cycles (Bertie through Cobleskill Fms.) most of New York State was overwhelmed by deposition of Helderbergian limestones (Fig. 10). These thick marine deposits were built up by biohermal and biostromal stromatoporoid and coral growth in conjunction with the accumulation of abundant debris of marine organisms. The type section of the Olney Limestone (Stop 4) exhibits some of the sedimentological features characteristic of this major transgression. Helderbergian facies and inferred environments have been discussed by Rickard (1962, p. 93-99; Fig. 26) and by Laporte (1969). See also Ciurca, 1978.

SUMMARY

The Bertie Group was deposited during multiple oscillations of the late Cayugan Sea. This resulted in a cyclic sequence of lithofacies reflecting sabkhal to subtidal depositional belts (Fig. 9). A minor oscillation from sabkhal to intertidal to sabkhal sedimentation is recorded by the upward transition from Camillus-Fort Hill and Oatka Formations.

The Fiddlers Green Formation records the major transgressive-regressive cycle of the Bertie Group. Victor B exhibits the farthest offshore facies of the Fiddlers Green Formation. The facies consists of fine-grained fossiliferous limestone parts of which contain well developed horizontal burrows and mottling due to bioturbation.

Supratidal conditions are indicated by the collapse and rip-up breccias of the Ellicott Creek Member. Supratidal to intertidal sedimentation is displayed by the Morganville and the Phelps Waterlime Members. Key indicators are mudcracks, cryptalgal structures (Fig. 3), and laminated sediments. Rare occurrences of ripplemarks, cross-bedding, and channel structures (Fig. 3) add to the support of this interpretation. The Victor Member, the thickest and most fossiliferous member of the Fiddlers Green Formation, records subtidal deposition under conditions approaching near normal salinity.

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ROADLOG

Cumulative Mileage	Miles From Last Point	Route Description
0	0	STOP #1. Roadlog starts at the roadcut along NY 88 near the NY Thruway (I-90) overpass, 0.5 mile north of NY 96 at Phelps.

STOP #1. The Onondaga Ls. is the highest unit present and contains a basal sandy layer (Springvale?) just above the unconformity with the Silurian Scajaquada Fm. Most of the Fiddlers Green Fm. is exposed along the highway. Camillus Fm. (Salina Gp.) is exposed north of the railroad overpass.

0.5	0.5	South to NY 96. Turn left (East).
5.7	5.2	Intersection of NY 14 turn north.
6.3	0.6	Intersection NY 318 turn right (east).
17.3	11.0	Junction U.S. 20. Turn left to Auburn.
19.4	2.1	Junction NY 90. Continue east on U.S. 20.
26.9	7.5	Turn left onto Clark Street.
27.0	0.1	Turn right onto Beech Street.
27.8	0.8	Turn left onto Canoga Jucntion.
28.3	0.5	Turn right into parking lot (before the bridge).
		STOP #2. OWASCO CREEK.

STOP #2. South of the bridge is an exposure of the stromatoporoid biostromal facies of the Cobleskill Fm. (Late Silurian). Downstream are poor exposures of the Fiddlers Green Formation.

28.6	0.3	Continue east on Canoga Junction Road. Turn left onto Wadworth Street.
28.7	0.1	Turn left onto Aurelius.
28.8	0.1	Turn left onto Wall Street.
29.6	0.8	Junction of NY 38. Turn right. Follow signs to U.S. 20 East.
29.9	0.3	Junction of U.S. 20. Turn left (to Skaneateles).
37.3	7.4	Junction of NY 321 North in Skaneateles continue east on NY 20.
39.1	1.8	Junction of NY 175. Turn left (to Marcellus).

42.6	3.5	Junction of NY 174. Turn left.
44.0	1.4	Turn right then next left on North Street (NY 174). Head toward Marcellus Falls.
45.3	1.3	STOP #3. THE COBLESKILL AND CHRYSLER FMS.

STOP #3. The Cobleskill and Chrysler Fms. are well displayed at this stop. A cherty facies is present in the Cobleskill Fm. and appears to be limited to the Syracuse area. Continue north on NY 174.

49.0	3.7	Junction of NY 5 at Camillus. Turn right onto NY 5 (Old Route to Syracuse).
52.9	3.9	Junction of NY 173. Turn right.
54.2	1.3	Junction of Split Rock Road. Turn right.
54.8	0.6	STOP #4. SPLIT ROCK QUARRY

STOP #4. There is a complete section of the Olney Fm. in the quarry. Above the Elmwood A is the Onondaga Ls. The uppermost Chrysler Fm. (E. Dev.) is exposed on the quarry floor near the entrance road.

55.4	0.6	Return to Junction NY 173. Turn right.
60.4	5.1	U.S. 11 Jct., turn right (So. Salina St.).
63.4	3.0	Junction of I-81, turn left (north) on I-81.
66.2	2.8	STOP #5. E. DEV. CARBONATES & ANTICLINE.

STOP #5. This E. Dev. carbonate sequence is one of the best exposures of the Manlius Gp. in central New York. Facies changes in the Olney Ls. (compared to the type section at Split Rock) are readily apparent. Stromatoporoid biostromes are common and become more important eastward.

66.7	0.5	I-481, Exit 16A north to Dewitt.
67.4	0.7	Exit to Rock Cut Road (Exit 1).
67.6	0.2	Turn left onto Rock Cut Road.
69.9	2.3	At the Stop Sign head south toward Jamesville.
70.2	0.3	Turn left. Stop at bridge over Butternut Creek.
		STOP #6. TYPE SECTION-FIDDLERS GREEN FM.

STOP #6. Butternut Creek contains fine exposures of this unit. Uppermost Fiddlers Green (mudcrack zone) occurs just above the falls. No Forge Hollow Fm. has been observed here but just up the road (toward the quarry) is a good exposure of the Cobleskill Fm. (celestite facies).

70.3	0.1	Return to main road. Turn right.

71.0	0.7	Turn right onto Woodchuck Hill Road.
72.6	1.6	Turn left onto Old Quarry Road.
73.0	0.4	STOP #7. ABANDONED QUARRY-FORGE HOLLOW FM.

STOP #7. The stratigraphic relationships of the Bertie-Cobleskill rocks are clearly shown at this quarry. The Williamsville Fm. has an unique fauna including Paracarcinosoma, Orbiculoidea, and Lingula. Overlying this unit are stromatoporoid beds of the Cobleskill Formation.

END OF ROADLOG