THE NEW YORK STATE GEOLOGICAL ASSOCIATION

42nd ANNUAL MEETING

MAY 1, 2, 3, 1970

CORTLAND, NEW YORK

NEW YORK STATE GEOLOGICAL ASSOCIATION

42nd Annual Meeting   May 1, 2, 3, 1970

FIELD TRIP GUIDEBOOK

William Graham Heaslip, Editor

Department of Geology, State University College at Cortland

Cortland, New York

Published by the New York State Geological Association. Additional copies available from the permanent secretary, Philip C. Hewitt, Chairman, Department of Geology and Earth Science, State University College at Brockport, Brockport, New York 14420.

PREFACE

Once again the annual meeting of the New York State Geological Association takes place in the region of Central New York after an absence of six years. This 42nd Annual Meeting devolves to an institution which has never before played host to the organization and whose Department of Geology had not yet come into official existence when Syracuse hosted its outstanding meeting in 1964.

It is, perhaps, because of our departmental youth here at Cortland that we have had to depend so heavily on the cooperation of geologists outside our college for articles and field trips. Gone are the days when the host department could assemble its Geology 1 and 2 trips for presentation to the Association and, if they were lucky, could muster one or two research-oriented trips if a graduate student or faculty member had reached that stage of his endeavor. Fortunately, we have become a little too professional for that, and field trips must demonstrate principles and meaningful relationships, rather than simply the local stratigraphic sequence or a series of "gee-whiz" features. The articles written by field trip leaders and others are splendid summaries of research, to date, in their areas and because of this, these guidebooks published each year by the Association are extremely valuable resources.

However, despite the growing professionalism, this organization has remained true to its original purpose: bringing together in the field geology graduate students, undergraduates, their instructors and other professionals to discuss matters of geologic interest for mutual enlightenment. The technical session initiated by John Prucha at Syracuse six years ago has become especially significant as a forum for student research papers dealing with the geology of New York State. Hopefully, the NYSGA will continue along the lines of increasing professionalism accompanied by increasing student participation.

The editorial contribution to the guidebook this year has been minimal. The copy for the guidebook was offset from original finished copy submitted by the individual authors; and I must acknowledge here my deepest gratitude for their splendid contributions and cooperation in meeting deadlines. I must also express great thanks to the members of the Department of Geology at Cortland for their help in the organization and operation of the meeting, and especially to John Fauth for taking charge of the technical session. Students in the department have, likewise, rendered great service in assembling the guidebook and performing ancillary tasks in running the meeting. Mrs. Alice Huntley, besides handling the secretarial work for two departments, typed announcements, abstracts and other portions of the guidebook.

David Price and the members of the Office of Continuing Education took complete charge of finances and arrangements for dinner and transportation as well as the binding of guidebooks and their contribution is hereby acknowledged. Lastly, I could think of no one more appropriate than John Wells to speak at the annual dinner and gratitude is expressed here.

William Graham Heaslip
Editor and President, 1970

THE GEOLOGIST'S TWENTY-THIRD

Geology is my major, I shall not want another.
It maketh me to go down in dark places;
It leadeth me into the running waters.
It ruineth my soles.
It leadeth me on the paths of the outcrops
for its name's sake.
Yea, though I search through the valleys,
I find the rocks on the hills,
I fear great evil when on the cliffs;
The hammers and chisels discomfort me.
It preparest a bedding plane for me in the
Presence of my brunton, it anointest my
Body with mud, my collecting sack runneth over.
Surely to goodness if I follow this vocation all the
Days of my life, I shall be buried in a landslide
forever.

Robert C. Rasely

BETHNIC COMMUNITIES OF THE GENESEE GROUP (UPPER DEVONIAN)

by

Jonathan W. Harrington
The University of Calgary

"The interest in a science such as geology must consist in the ability of making dead deposits represent living scenes."

---Hugh Miller

Introduction

The New York Devonian is unique in its completeness, fossil content, numerous outcrops, and relatively undisturbed nature. It is the standard reference section for North America and displays a classic example of facies transition. Stratigraphic and paleontologic investigation over the past century has resulted in a wealth of information. "Despite this, perhaps another century of rigorous study will be required before a thorough understanding of its paleontology, lithology, stratigraphy and paleoecology can be attained." (Rickard, 1964).

It is doubly apropos that we examine the Genesee Group in the Cortland area. The rocks of this region and their organic remains are of considerable historical interest, having received attention since the earliest days of geological investigation in New York State. In fact, the presence of fossil shells in the Devonian rocks of New York was first noted in 1751 at a hillside outcrop in Cortland County by John Bartram, a member of Lewis Evans' Onondaga expedition (Wells, 1963).

Previous Work

The early stratigraphic work on the Upper Devonian of New York was done mainly by James Hall, J.M. Clarke, and H.S. Williams, between 1840 and 1915. These workers subdivided the succession, described the faunas and attempted to correlate along the strike. Due to complex interfingering of the argillaceous western sequence with the thicker arenaceous eastern sequence, correlations proved difficult. Only in the 1930's with the work of Chadwick (1935) did it become apparent that the major facies had migrated across the basin of deposition as the Catskill Delta prograded.

Since 1942 investigation of the Upper Devonian has emphasized physical stratigraphy. The works of Sutton, J.F. Pepper, W. deWitt, Jr., and G.W. Colton have outlined the stratigraphy of the Senecan Series. The cyclic repetition of widespread black shales in western New York has been used to subdivide the succession. Paleontologic studies have, until recently, consisted of clarification and classification of forms originally described by Hall and Clarke between 1847 and 1915. The rarity of new discoveries signifies the accuracy of their monumental works.

Stratigraphy

The Genesee Group of New York represents the lower half of the Finger Lakes Stage. It includes the ammonoid zones of Ponticeras perlatum and Manticoceras simulator correlative with the upper part of the Iα and the lowermost portion of the I(β)γ zones in Europe.

The sequence consists of a series of complexly interfingering units representing several major depositional phases. Throughout most of the area, the group is underlain by the Tully Limestone, which contains the zone of Pharciceras amplexum and marks the base of the Upper Devonian. It is overlain by the Middlesex dark shale and its eastern extension - the Montour shale (base of the "Enfield"), containing the zone of Probeloceras lutheri.

The Genesee group is basicly a regressive sequence marked at the top by a minor transgression (see Fig. 1). The units rapidly thicken and become coarser to the east; from 450 feet of fine-grained offshore marine sediments in the Naples area to over 1500 feet of coarse marine and continental sands and silts in the Oneonta meridian.

Over the past 50 years (largely based on the works of Williams, 1913) a nearshore zonation of the New York Upper Devonian has evolved utilizing the appearance or extinction of brachiopod species. Any extensive zonation of benthonic organisms must be critically evaluated. However, these zones seem to be quite reliable within certain limits and may be easily recognized in the field. They are clearly time transgressive, their limits changing across the basin of deposition (Williams, 1913).

The zones, in fact, are closely tied to sedimentary types and consist of discrete fossil communities, whose areal extent is compatable with the biotic attributes. These communities may be considered in terms of (1) feeding types and vagility, (2) species diversity and population density, (3) animal-sediment relationships, and (4) morphologic adaptations of specific forms.

Feeding Types

The feeding types of benthic animals are of considerable significance as they reflect conditions determined by the physical environment. Recognition of feeding types in fossil invertebrates is often tenuous. At best, only generalizations may be made. In fact, many animals display multiple feeding types. However, by analogy with recent forms, by shell morphology,

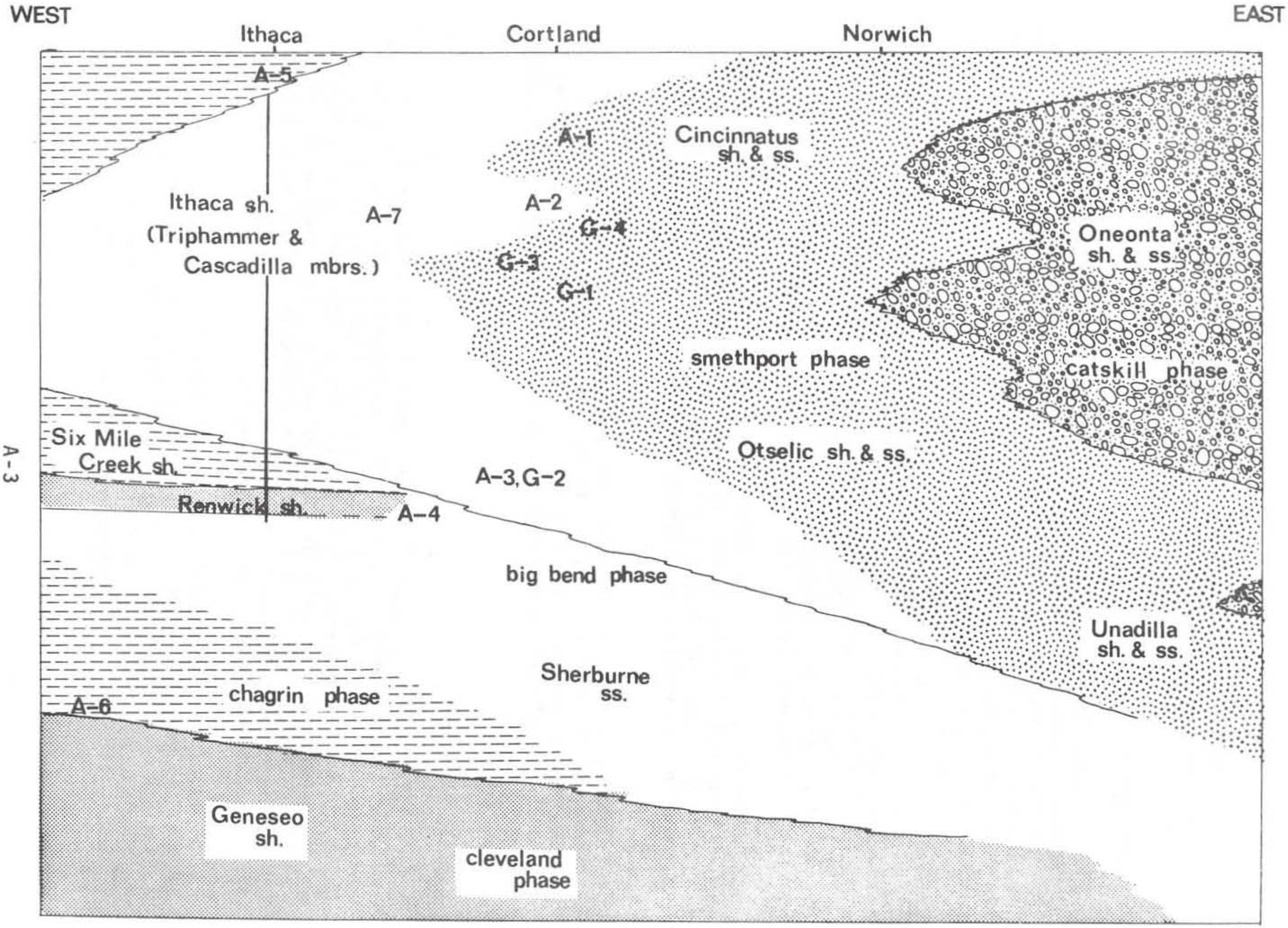


Fig. 1 Stratigraphic Relationships of the Genesee Group

and by determination of infaunal or epifaunal habit reasonably accurate inferences may be drawn.

Filter-feeders

Included here are epifaunal and infaunal animals which derive nourishment from suspended micro-organisms and particulate organic matter. Infaunal filter-feeders are most abundant in well-sorted sands and silts. They derive their nourishment from food carried by currents. Therefore, the greater the current the greater is the available food supply, resulting in an increased abundance of forms up to the point where currents tend to move sediment into their burrows (Driscoll, 1969).

This type is represented by many polychaetes and other vermes that may leave recognizable burrows, and by some pelecypods, such as <u>Grammysia</u>, <u>Schizodus</u>, <u>Edmondia</u>, and <u>Cypricardella</u>. Bivalves are characterized by relatively massive, equivalved shells, absence of byssal notch or gape, and by a pallial sinus in siphonate genera. Stanley (1968) has shown that siphonate forms are virtually absent from the Paleozoic.

Filter-feeders which live above the sediment-water interface are much more widespread, thriving on mud, silt and fine sand bottoms. They benefit from the increased food supply provided by higher velocity currents without encountering the problems of sedimentation that restrict infaunal filter-feeders.

Bryozoa, brachiopods, crinoids and sponges are all quite definitely epifaunal filter-feeders. Certain pelecypods also belong in this group. They are characterized by the presence of a byssal notch and inequivalved shells, as illustrated by <u>Actinopteria</u>, <u>Leptodesma</u>, <u>Goniophora</u>, <u>Cornellites</u>, and <u>Modiomorpha</u>.

Deposit feeders

This feeing type includes forms that directly ingest particulate food matter. Deposit feeders are particularly abundant in fine-grained deposits indicative of low-current velocities. Fine particulate organic material is deposited by such currents. In higher current velocity regimes, it remains in suspension and is unavailable as a food source. The reduction of current velocities eventually introduces detrimental effects. Interstitial circulation becomes restricted, causing the buildup of toxic by-products which are reflected in a decrease in deposit feeding forms.

Included in this type are many of the worm phyla, some pelecypods, and possibly certain ophiuroids. Although it is difficult to generalize, deposit feeding bivalves are usually small, thin and relatively unornamented. The feeding type is particularly well developed in the protobranchs; the nuculoids, <u>Palaeoneilo</u> and <u>Pterochaenia</u> are representative.

Carnivore-Scavengers

There is no clear-cut distinction between these feeding types. Their distribution depends on the abundance of a food supply, rather than on any sediment type. Forms are locally abundant, especially in quiet water environments characterized by the accumulation of organic debris. Virtually all carnivores and scavengers are vagrant epifauna or are nekton. In the strictest sense, coelenterates are carnivores, feeding on suspended planktonic micro-organisms. These microphragous carnivores are largely restricted to well-circulated waters for the same reasons that sessile filter-feeders are.

Representatives of this group are determined largely by analogy to modern forms. Asteroids are typically macrophragous carnivores. Many gastropods may belong here, but others may be herbivores or deposit feeders. Modern forms display highly diverse feeding habits, which are not reflected in shell morphology.

Diversity and Density

Population Density

In general terms the relative density of fossil communities seems to vary from low densities on offshore mud bottoms to relatively high densities onshore silt and fine sand substrate. This appears to be related to available nutrient levels, the ultimate food sources being terrigenous. Theoretically, the very nearshore areas characterized by rapidly shifting sediments have a low population density and few species. The high current activity results in high substrate mobility. The characteristic fauna being dominated by vagrant filter-feeders. By their very nature, these shallowest water environments are probably not normally preserved even under stable geographic conditions (Ager, 1965).

Species Diversity

The gradient in terms of diversity is more complex. Both shallow and deep water environments display low species diversity. The greatest numbers of species seem to have occupied silt and mud bottoms at intermediate depths. The nearshore diversity low may be due to salinity, temperature, and desiccation stress conditions (Bretsky, 1969), as well as the high degree of substrate mobility (Purdy, 1964). The offshore, low-diversity environment appears to reflect an area of low primary benthonic productivity and poor circulation with low levels of oxidation. This is expressed, not only in the low diversity, but also in the color and texture of the sediments, and to some extent in morphological modifications of indigenous species.

Diversity reaches a high point in fine silt and mud bottoms of intermediate depths. This environment is characterized by a luxuriant encrusting epifauna, as well as by maximum-size development of a number of species. Ager (1965) considers maximum size attainment as a guide to optimum conditions.

Animal-Sediment Relationships

As has already been stated the distribution of many organisms bears a relation to sediment type and current velocity. Infaunal burrowing forms and their characteristic trace fossils, are common at all depths. Infaunal filter-feeders are particularly abundant in shallow-water sands where they are characteristically adapted for deep vertical burrowing (Rhoads, 1966; 1967). This dominance appears to relate to the protection from environmental stress, such as temperature and salinity fluctuation, and desiccation (McAlester and Rhoads, 1967). Deposit-feeding forms are abundant in fine-grained, organic-rich sediments characteristic of deeper, quieter waters. In this environment near-surface horizontal burrows and tracks and trails predominate.

In addition to the orientation of trace fossils, the amount of sediment reworking is significant. Deposit-feeders are increasingly abundant in quieter waters. As Moore and Scruton (1957) have shown in the case of the Mississippi delta, the relative amount of bioturbation trends from insignificant in laminated sediments, through an intermediate phase of mottled structures, to total reworking in fine-grained homogenous sediments.

Morphologic Adaptation

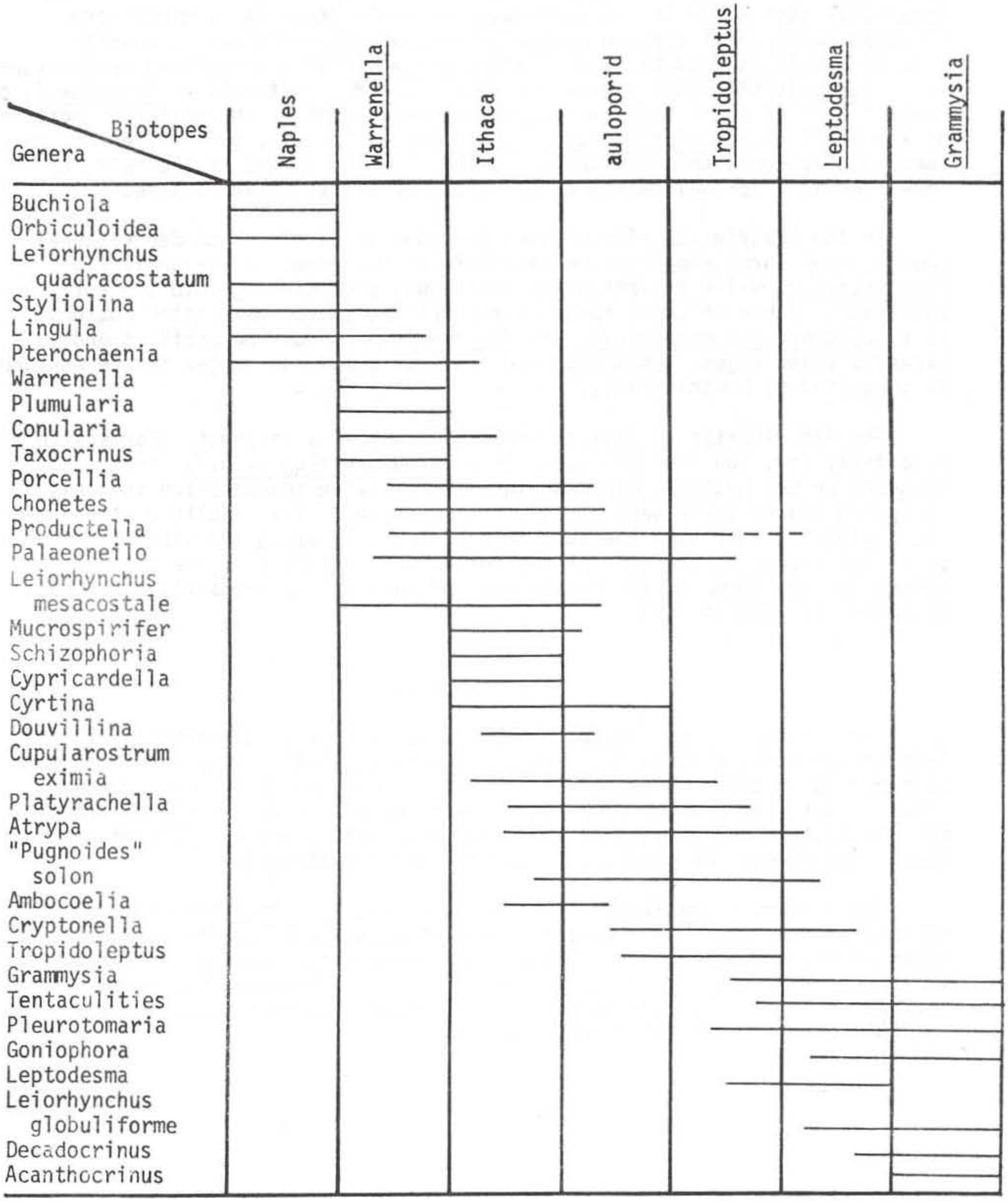
In the interpretation of fossil communities of particular importance is consideration of morphologic adaptation, especially of the abundant epifaunal brachiopods. Copper (1966) has shown that their distribution may often be closely correlated with depositional phases. Morphologic adaptations are largely in response to problems of support, separation of inhalant and exhalant currents, and sedimentation.

Brachiopods anchor, stabilize or affix themselves to the substrate or to host objects. They successfully invaded mud bottoms, living and dead shells forming a common base for attachment. In some forms, the distal end of the pedicle may have split into rootlets anchoring it directly in the sediment, as in the modern genera, Terebratulina and Chlidonophora.

Many of these forms (as well as other filter-feeders such as crinoids) were somewhat elevated above the low velocity currents near the sediment-water interface into areas where more rapid currents transported suitable food supplies. This undoubtedly allowed them to colonize a wider range of environments.

In the neanic stages probably all brachiopods possessed a functional pedicle attaching the individual to, and supporting it above, the substrate. Some forms tend to show an almost complete closure or covering of the pedicle opening in later life stages. Typical pedunculate forms occur on

Fig. 2. Inferred Distribution of Abundant Genera in the Genesee Group



(1) Grammysia Biotope

Communities characterized by large numbers of the infaunal filter-feeder, Grammysia, and the byssiliferous epifaunal genus, Goniophora, inhabited coarse, unstable sand bottoms in the nearshore Smethport depositional phase. The environment is highly variable in lithology and faunal composition. Strongly developed species dominance and low diversity are characteristic. Brachiopods are typically sharply costate and possess well-developed fold and sulcus. Locally developed in more sheltered areas are dense colonies of crinoids (Decadocrinus and Acanthocrinus) or hexactinellid sponges (Actinodictya placenta). In these areas where there is an accumulation of organic debris, gastropods, asteroids, and ophiuroids are abundant.

(2) Leptodesma Biotope

On silt and shale substrates in areas of moderate current activity are developed communities of large numbers of filter-feeding epifaunal species, with smaller numbers of deposit feeding genera. In general, species diversity and population density are moderate. Common fossils are: Atrypa, "Pugnoides", Cryptonella, Pleurotomaria, Leiorhynchus globuliforme, Goniophora and Leptodesma.

(3) Tropidoleptus Biotope

This community represents an adaptation to stable, organic-rich, silt and mud bottoms. It is characterized by an abundant brachiopod epifauna, especially of large numbers of the spiriferid, Platyrachella. Other abundant genera are: Productella, Cupularostrum, Atrypa, "Pugnoides", Ambocoelia and Tropidoleptus.

(4) Auloporid Biotope

This sporadically developed biotope is characterized by an abundant filter-feeding epifauna in association with the deposit-feeding genus, Palaeoneilo. Many brachiopods display morphological adaptations to a soft mud substrate (e.g. frilled atrypoids). In association with these forms is a rich encrusting epifauna of bryozoans and auloporid corals. The presence of these forms precludes rapid burial, and indicates rather low and discontinuous sedimentation. The genera present represent an admixture of forms from the Ithaca and Tropidoleptus biotopes. This is not the Cladochonus subfauna of Williams (1913).

(5) Ithaca Biotope

This community is well developed on mud bottoms in areas of moderate currents. It is characterized by a highly diverse epifauna of brachiopods (Mucrospirifer, Chonetes, Productella) and the infaunal filter-feeding bivalve, Cypricardella. Moderate species diversity and low population density are typical of the biotope.

(6) Warrenella biotope

A mixed association of benthic and pelagic forms characterized by poorly oxygenated, offshore mud bottoms. Brachiopods typically develop low, expanded outlines (i.e. Warrenella and Leiorhynchus mesacostale). Deposit feeding pelecypods, such as Palaeoneilo and Pterochaenia are abundant. Linguloid brachiopods and small crinoids (i.e. Taxocrinus) are locally developed, as are the microphagous carnivores (?) Plumularia and Conularia. Species diversity and population density are low.

(7) Naples biotope

Pelagic species comprise the majority of this fauna. The reduced mud bottoms supported rare deposit-feeders (i.e. Pterochaenia) and occasional linguloids. More typical filter-feeders (Orbiculoidea and Leiorhynchus quadracostatum) are interpreted as having been epiplanktonic, living attached to floating plant material in the well-oxygenated surface waters.

Controlling Factors

The benthic communities of the Genesee Group bear similarities to other paleoecologic analyses of the New York Upper Devonian. However, differences in the distribution and association of genera are apparent.

Physical controls may have differed significantly throughout the Upper Devonian. McAlester (1960) considered bottom stability and current velocities to control distribution of pelecypod associations in the Chemung stage. Whereas, Sutton and others (1966) stressed variations in rate of sedimentation and in salinity in their study of the Sonyea Group. On the other hand, the communities may have evolved through this time interval in the manner suggested by Bretsky (1968). Such changes in environmental preference need not be reflected by any morphologic modifications.

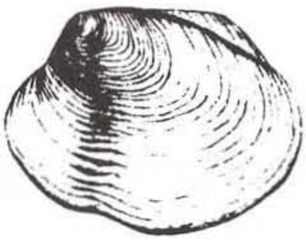
The environmental conditions in the Genesee Group appear to represent a complex interaction of factors of substrate, rate of sedimentation, current velocity, salinity and oxygenation. The strongest controls on distribution are probably bottom conditions and trophic levels. The control is certainly not primarily bathymetric as has been suggested for certain communities of Silurian brachiopods (Ziegler, 1965; Cocks, 1967). Nor is there any evidence that the brachiopods can be separated into euryhaline (tolerant) and stenohaline (restricted) groups as suggested by Ivanova (1962).

Plate 1. Common Genesee Fossils

Palaeoneilo

Leptodesma

Goniophora x 1/2



Grammysia x 1/2

Cypricardella

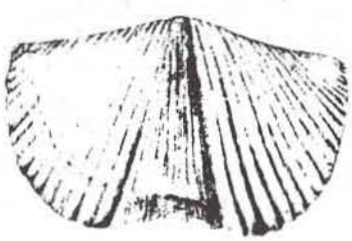
Loxonema

Pleurotomaria

Pterochaenia

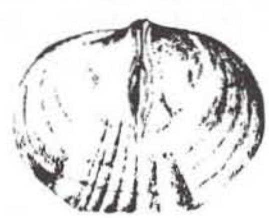
Mucrospirifer

Cupularostrum



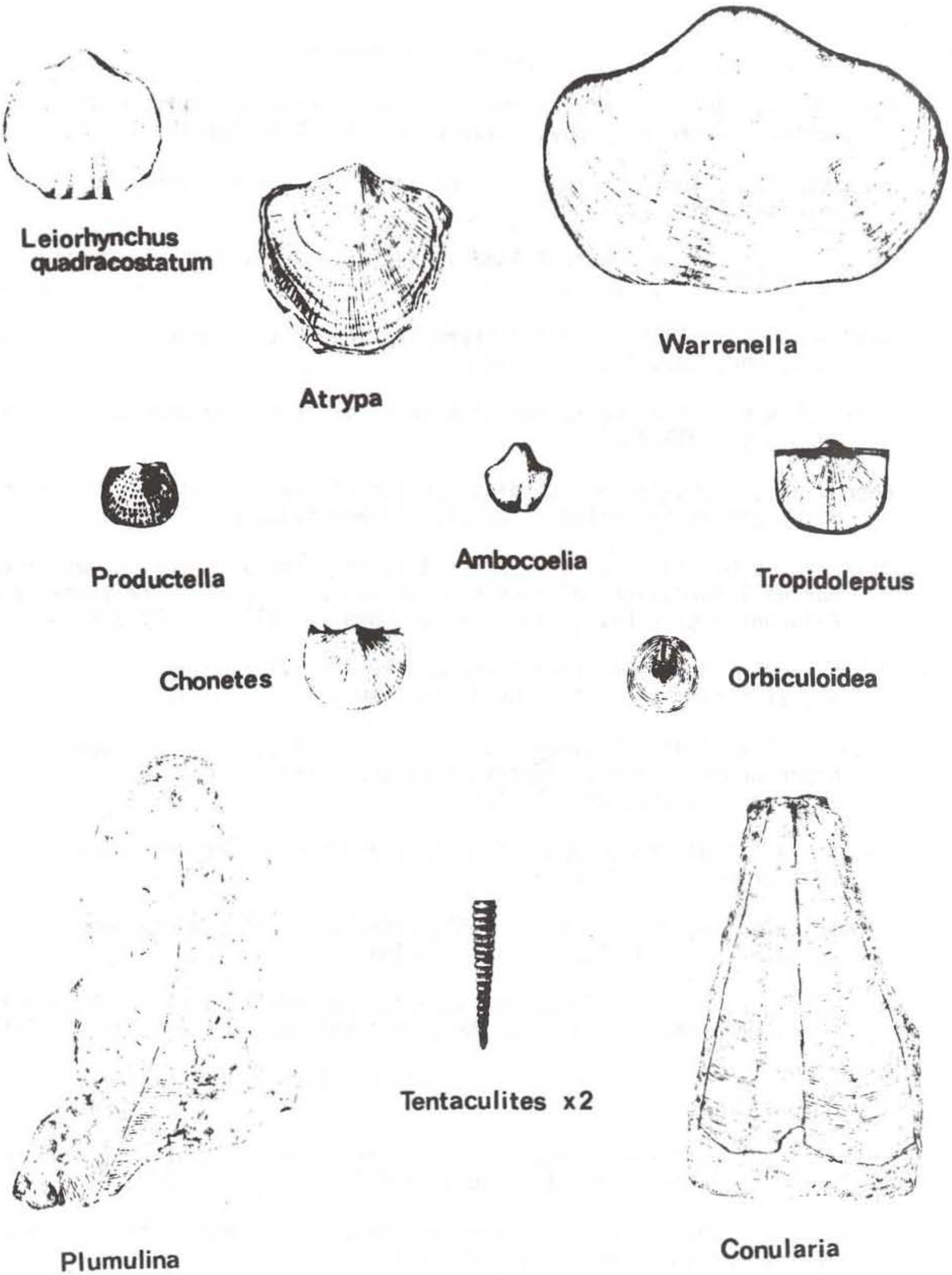
Platyrachella

Pugnoides



Leiorhynchus mesacostale

Plate 2. Common Genesee Fossils



Selected References

Ager, D.V., 1965, The adaptation of Mesozoic brachiopods to different environments. Palaeogeography, Palaeoclimatol., Palaeoecol., 1: 143-172.

Bretsky, P.W., 1968, Evolution of Paleozoic marine invertebrate communities. Science, 159: 1231-1233.

__________, 1969, Central Appalachian Late Ordovician communities. Bull. Geol. Soc. Am., 80: 193-212.

Chadwick, G.H., 1935, Faunal differentiation in the Upper Devonian. Bull. Geol. Soc. Am., 46: 305-342.

Cocks, L.R.M., 1967, Depth patterns in Silurian marine communities. Marine Geol., 5: 379-382.

Copper, P., 1966, Ecological distribution of Devonian atrypid brachiopods. Palaeogeography, Palaeoclimatol., Palaeoecol., 2: 245-266.

Driscoll, E.G., 1969, Animal-sediment relationships of the Coldwater and Marshall formations of Michigan, in K.S.W. Campbell, Stratigraphy and Palaeontology - Essays in Honor of Dorothy Hill, p. 337-352.

Fagerstrom, S.A., 1964, Fossil communities in paleoecology: their recognition and significance. Bull. Geol. Soc. Am., 75: 1197-1216.

Ivanova, E.A., 1962, Ecology and development of Silurian and Devonian brachiopods of the Kutznetsk, Minussinsk and Tuvinsk basins. Tr. Paleontol. Inst., 88: 1-150.

Lamont, A., 1934, Brachiopod morphology in relation to environment. Cam. Lime Gravel, 8: 216-219.

Menard, H.W. and Boucot, A.J., 1951, Experiments on the movement of shells by water. Am. J. Sci., 249: 131-151.

McAlester, A.L., 1960, Pelecypod associations and ecology in the New York Upper Devonian. Geol. Soc. Am., Ann. meeting, Denver, Abstr., 1960: 157.

__________ and Rhoads, D.C., 1967, Bivalves as bathymetric indicators. Marine Geol., 5: 383-388.

Moore, D.G. and Scruton, P.C., 1957, Minor internal structures of some Recent unconsolidated sediments. Bull. A.A.P.G. 41 (12): 2723-2751.

Purdy, E.G., 1964, Sediments as substrates, in J. Imbrie and N.D. Newell, Approaches to Paleoecology, 238-271.

Rhoads, D.C., 1966, Depth of burrowing by benthonic marine organisms; a key to nearshore-offshore relationships. Geol. Soc. Am., Ann. Meeting, San Francisco, Abstr., 1966: 176.

____________, 1967, Biogenic reworking of intertidal and subtidal sediments in Barnstable Harbor and Buzzards Bay, Massachusetts. J. Geol., 75 (4): 461-476.

Rickard, L.V., 1964, Correlation of the Devonian rocks in New York State, N.Y. State Mus. & Sci. Service, Map and Chart Series: No. 4.

Schmidt, H., 1937, Zur Morphogenie der Rhynchonelliden. Senck. leth., 19: 22-60.

Stanley, S.M., 1968, Post-Paleozoic adaptive radiation of infaunal bivalve molluscs - a consequence of mantle fusion and siphon formation. J. Paleont., 42: 214-229.

Sutton, R.G.; Bowen, Zeddie, and McAlester, A.L., 1966, Multiple-Approach Environmental Study of the Upper Devonian Sonyea Group of New York. Geol. Soc. Am., Ann. Meeting, San Francisco, Abstr., 214-215.

Wells, J.W., 1963, Early investigations of the Devonian System in New York, 1656-1836. Geol. Soc. Am. Sp. Paper 74, 74 p.

Williams, H.S., 1913, Recurrent Tropidoleptus zones of the Upper Devonian in New York. U.S.G.S., Prof. Paper 79.

Ziegler, A.M., 1965, Silurian marine communities and their environmental significance. Nature, 207: 270-272.

Trip A - Benthic Communites of the Genesee Group (Upper Devonian)

Selected Exposures

1. Small quarry on West River Road, just south of Bloggett Mills, Cortland Co.

This exposure in the Upper Ithaca formation (correlative with the Triphammer member in the Cayuga Lake meridian) consists of fine shales and siltstones of the Smethport depositional phase. The Leptodesma biotope is represented by an abundant fauna, consisting of the spiriferid, Platyrachella, and Leptodesma, with numerous large pectinoid and mytiloid pelecypods. Most brachiopods, especially the rhynchonellids, are conspicuously absent.

2. Hillside quarry, 1 mile south of Cortland on Rte 90.

At this outcrop in the upper Ithaca the Big Bend phase is represented by a sequence of gray shales and siltstones, with some lenses of leached coquinite. An extremely varied benthic fauna is present. Especially abundant are Leiorhynchus mesacostale and "Pugnoides" solon.

3. Outcrop in Homer Gulf on Rte 41A, 4 miles north of Cortland.

Ponticeras perlatum has been identified from exposures in Homer Gulf. This places the section in the lower portion of the Ithaca formation, probably correlative with the Renwick shale member. The lithology is extremely variable; consisting mainly of gray and reddish shales and siltstones. The fauna contains elements of both the Warrenella and Ithaca biotopes. Particularly common are: Conularia, Plumularia, Mucrospirifer, "Pugnoides", Cupularostrum eximia, Taxocrinus and linguloid brachiopods.

4. Fitzpatrick quarry ("Frozen Ocean"), north of Omro, Cayuga Co.

This is the northernmost exposure of the Ithaca formation in this area. Here, a series of reddish brown and dark gray shales represents the lowermost Renwick member, and possibly part of the Cornell member of the Sherburne (Smith, 1935). The sparse fauna contains elements of the Naples and Warrenella biotopes. Especially abundant are well preserved specimens of Leiorhynchus mesacostale.

Lunch Stop - Stewart Park, Ithaca.

5. Fall Creek, Ithaca

This exposure, and that of adjacent gorges, constitutes the type section of the Ithaca formation. The sequence displays a complex interfingering of at least four of the biotopes that have been discussed.

The top of the Sherburne formation is marked by the presence of the Warrenella biotope (at the base of the falls). The commonest fossils are: Warrenella laevis, Palaeoneila filosa, Pterochaenia fragilis, Chonetes lepida, Taxocrinus ithacensis, Porcellia nias and Styliolina fissurella.

Above, in the lower vertical wall of the gorge is the Renwick member of the Ithaca, a reddish black fissile shale containing a sparce Naples fauna. Lingula complanata, Leiorhynchus mesacostale, Orbiculoidea lodensis and Styliolina fissurella are the commonest fossils.

In the upper portion of the vertical cliffs are gray shales and siltstones representing the Six Mile Creek member, containing a Tropidoleptus fauna with Platyrachella mesastrialis, Rhipidomella vanuxemi, Cyrtina hamiltonensis, Pleurotomaria capillaria and Cryptonella endora.

Above the falls the upper 300' of the Ithaca formation is represented by the Cascadilla and Triphammer members. At the base of the Cascadilla member the Ithaca biotope contains an abundant fauna, primarily of brachiopods. Especially common are: Leptostrophia, Cyrtina, Productella, Atrypa, Schizophoria, Leiorhynchus mesacostale, Cypricardella and Palaeoneilo.

The top of the Ithaca is marked by the recurrence of the Warrenella biotope, which is exposed at Forest Home, above the Cornell campus. Between these two zones are a sequence of virtually barren shales with a sparse Naples fauna, and at least one minor incursion of the Ithaca biotope.

6. Hubbard quarry, on Rte 89 at Lively Run, 1.5 miles northeast of Interlaken, Seneca County.

This is one of the few places where the contact of the Geneseo black shale and the Sherburne formation can be seen.

The uppermost 6' of the Geneseo carry typical fossils of the Naples biotope: Barriosella spatulata, Orbiculoidea lodensis, Schizobolus truncatus, Leiorhynchus quadracostatum, Pterochaenia fragilis, Ponticeras perlatum, and fish and plant fragments.

In the lower Sherburne the following fossils occur: Chadochonus sp., Leiorhynchus quadracostatum, Loxonema noe, Palaeotrochus praecursor, Panenka sp., brevicone nautiloids and Ponticeras perlatum.

This fauna of mixed benthonic and pelagic types is similar to the "Naples fauna" of the West River shales further to the west. It seems to represent the environments of the Warrenella biotope.

7. Roadcut on Rte 13, just east of Dryden, Tompkins Co.

This exposure in the lower Triphammer member is one of the most richly fossiliferous outcrops of the Ithaca formation. It contains abundant encrusting epifauna representing the auloporid biotope, with minor incursions of the Ithaca biotope from the west and the Tropidoleptus from the east. Diversity is at a maximum, with maximum size development of Leiorhynchus mesacostale, Atrypa reticularis and Platyrachella mesastralis. Other common fossils are: "Pugnoides" solon, Porcellia nias, Mucrospirifer posterus and Cyrtina hamiltonensis.