Faunal Assemblages in the Lower Hamilton Group in Onondaga County, New York

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INTRODUCTION

This report summarizes a quantitative study of the paleoecology of the Lower Hamilton Group in Onondaga County. This paper describes the faunal elements recognized and the ecological categories into which the taxa were grouped. The study confirms and extends the important works of Cooper (1930, 1933). Information concerning the multivariate statistical techniques, sedimentological data, and detailed analysis of the environments studied will be published elsewhere.

In Onondaga County the Hamilton Group directly overlies the Seneca Limestone of the Onondaga Formation. Samples were taken from the Marcellus Formation, Skaneateles Formation, and the lower portion of Ludlowville Formation (Fig. 1). Although Rickard (1975, p. 6) notes that the Cherry Valley merges with the Seneca Member of the Onondaga Limestone in the western part of the State, we have followed the traditional course in treating the Cherry Valley with the Hamilton Group.

PELAGIC ASSEMBLAGES OF THE MARCELLUS FORMATION

The Union Springs, Chittenango, and Cardiff Members of the Marcellus Formation are characterized by pelagic and epipelagic faunas. The sediments consist of either black shale or black limestone. The weight percent of organic matter in these rocks ranges about 4.4 percent. The delicate laminations and fine-grain sizes in these sediments indicates quiet-water conditions in which the sediments were not disrupted by burrowing animals. The presence of 4 or 5 percent of organic carbon is enough to produce reducing conditions on the seabed. The regional distribution of the black rocks in the Marcellus shows that these sediments were deposited offshore in relatively deep and still water under reducing conditions.

As expected, few species occur in the black sediments of the Marcellus. The main ecological categories are planktonic filter-feeders (Styliolina fissurella), nektonic predators represented by various ammonoids and nautiloids, epiplanktonic filter-feeders similar to Pterochaenia fragilis, Buchiola, Lunulacardium, Leiorhynchus limitare and Longispina mucronata, and terrestrial wood. The wood constitutes vegetation which floated out to sea, became water logged, and sank into the foul muck of the Marcellus Sea. The epiplanktonic oranisms probably were attached to floating seaweeds and in some situations, drifting logs.

Four different pelagic or epipelagic assemblages can be identified in the Marcellus. One is dominated by Styliolina fissurella, a minute cone-shaped organism of unknown affinities (Fisher, 1962). The second is

Group	Formation	Member	Thickness	Description
Hamilton	Moscow	Windom	180'	shale & siltstone
		Portland Point	9-10'	limestone & shale
	Ludlowville	Owasco	1-3'	siltstone
		Spafford	25'	shale
		Ivy Point	50-60'	siltstone & shale
		Otisco	160-180'	shale & siltstone
		Centerfield	30'	calcareous siltstone
	Skaneateles	Butternut	100-200'	shale & siltstone
		Pompey	60'	shale & siltstone
		Delphi Station	100'	shale & siltstone
		Mottville	45'	limestone & shale
	Marcellus	Cardiff	125-200'	shale
		Chittenango	100'	black shale
		Cherry Valley	3'	limestone
		Union Springs	13-15'	shale & limestone

Figure 1. Stratigraphic section of Middle Devonian Hamilton Group in Onondaga County, New York.

abundant in Pterochaenia fragilis but also includes some cephalopods. The third is composed mostly of Leiorhynchus limitare, whereas the fourth consists of terrestrial wood, cephalopods, and several bivalves. Low diversity and strong dominance is observed in all of these assemblages. These observations reflect stressed consitions caused by quiet water and the lack of dissolved oxygen and the fact that only a few organisms were able to exploit the pelagic and epipelagic life styles. Some of the bedding planes in the Marcellus are covered with Styliolina fissurella or Leiorhynchus limitare. These are believed to be due to catastrophic mortality of pelagic and epipelagic organisms, perhaps owing to being transported into surface waters with no dissolved oxygen. This killed the animals which then separated from their floating substrates to become buried in the Marcellus black muck. In other instances, the density of fauna is low and normal rates of mortality were involved.

A listing of the faunal and ecological classification of each assemblage follows (Tables 1, 2, 3, and 4). The percentage given is the average occurrence for all smaples of the assemblage. This format will be followed in subsequent tabulations.

CHERRY VALLEY LIMESTONE

The Cherry Valley Limestone contains a transitional bottom-dwelling pelagic fauna. The main pelagic taxa are cephalopods whereas the benthos include brachiopods, crinoid debris, trilobites, Aulopora, Coleolus? sp., and some questionable algal lumps. A depth of less than 100 ft is denoted by the algae and vertical cephalopod shells. The fauna and lithology testify to oxygenated and agitated conditions. Cherry Valley constitutes an interval when bottom-dwelling organisms were able to colonize the seafloor. This environment was short lived, quiet water and anaerobic conditions soon resumed during Chittenango time. The Cherry Valley is relatively thin and poorly exposed in this area, therefore we have not been able to compile data from the Cherry Valley that are comparable with those from the other units examined.

BOTTOM DWELLING ASSEMBLAGES OF THE LOWER HAMILTON

Seven bottom-dwelling communities, two of which are subdivided into two subassemblages each are recognized in the upper Marcellus, Skaneateles, and Ludlowville Formations. The ecological structures of the communities are relatively simple. The two most abundant foodstuffs consist of plankton and organic detritus. As noted by Walker (1972) and numerous others (e.g. Tipper, 1975), the most abundant species are concentrated in different ecological categories where the advantage is of minimizing competition between the most abundant forms of a community. Within a single assemblage, each niche is dominated by one taxon which usually accounts for at least half of all the specimens in that niche. Again, this results in decreased intensity of competion.

The Tropidoleptus carinatus assemblage (Table 5) of the Mottville, Pompey, and Centerfield is dominated by filter-feeding reclining brachiopods. These brachiopods, the deeply attached endobyssate pelecypods and the burrowing protobranch pelecypods are all adapted for life in soft sediments. Both diversity and dominance are relatively high whereas equitability is low, thus demonstrating that significant packing of niches has not taken place. For example, the four most abundant species constitute almost 80 percent of the entire assemblage and Tropidoleptus carinatus accounts for almost half of the individuals.

The Nuculoidea-Bembexia community (Table 6) of the Delphi Station dwelt in a quiet-water habitat at moderate depths. Abundant organic detritus and microorganisms provided a food supply for approximately 29 percent of deposit feeders, mostly infaunal nuculoid pelecypods. Bottom-dwelling filter-feeders account for about 45 percent of the assemblage; these are mostly small chonetid brachiopods which recline on the seafloor, endobyssate pelecypods, and pedicle-attached brachiopods. Abundant epifaunal herbivorous gastropods grazed on algal mats and other submarine

Table 1. Faunal and ecological classification of *Styliolina fissurella* assemblage.

Planktonic filterfeeder (97%)	
	Styliolina fissurella
Nektonic predator (2%)	
	Orthocone sp.
	Goniatite sp.
	Agoniatites vanuxemi
	Striatoceras
Epiplanktonic filterfeeder (1%)	
	Pterochaenia fragilis
	Longispina mucronata
	Leiorhynchus limitare
	Buchiola sp.
	Lunulacardium sp.
Unclassified (<1%)	
	Wood fragments

Table 2. Faunal and ecological classification of *Pterochaenia fragilis* assemblage.

Epiplanktonic filterfeeder (76%)	
	Pterochaenia fragilis
	Lunulacardium sp.
	Panenka sp.
	Buchiola sp.
	Leiorhynchus limitare
Nektonic predator (21%)	
	Orthocone sp.
	Goniatites
Unclassified (3%)	
	Wood fragments
Planktonic filterfeeder (<1%)	
	Styliolina fissurella

Table 3. Faunal and ecological classification of *Leiorhynchus limitare* assemblage.

Epiplanktonic filterfeeder (84%)	
	Leiorhynchus limitare
	Pterochaenia fragilis
Unclassified (16%)	
	Wood fragments

Table 4. Faunal and ecological classification of "wood assemblage".

Unclassified (74%)	
	Wood fragments
Nektonic predator (20%)	
	Orthocone sp.
	Goniatites sp.
Epiplanktonic filterfeeder (6%)	
	Panenka sp.

Table 5. Faunal and ecological classification of *Tropidoleptus carinatus* assemblage.

Reclining filter-feeder (64%)
- *Tropidoleptus carinatus*
- *Chonetes* sp.
- *Mucrospirifer mucronatus*
- *Protoleptostrophia perplana*
- *Atrypa reticularis*

Infaunal deposit-feeder (13%)
- *Nuculoidea* sp.
- *Nuculites oblongatus*
- *Palaeoneilo emarginata*

Epifaunal browsing herbivore (8%)
- *Bembexia sulcomarginata*
- *Bellerophon* sp.
- *Palaeozygopleura hamiltonae*
- *Holopea* sp.

Deeply buried endobyssate filter-feeder (5%)
- *Sphenotus* sp.
- *Modiomorpha* sp.
- *Modiella pygmaea*
- *Glossites* sp.
- *Paracyclas* sp.
- *Grammysia* sp.
- *Macroden* sp.
- *Goniophora* sp.

Low-level rooted epifaunal (2%)
- *Athyris cora*
- *Mediospirifer audaculus*
- *Leiorhynchus laura*
- *Ambocoelia embonata*
- *Pholidops hamiltonae*
- *Rhipodomella* sp.
- *Pterinopecten* sp.
- *Pseudoaviculopecten* sp.
- *Camarotoechia*

Epifaunal crawling or ploughing collector (2%)
- *Greenops boothi*
- *Hyolithes* sp.

Shallow-buried endobyssate filter feeder (1%)
- *Cornellites flabella*
- *Actinopteria* sp.

Nektonic carnivore (<1%)
- *Orthocone* sp.
- *Spyroceras* sp.

Table 6. Faunal and ecological composition of Nuculoidea-Bembexia assemblage.

Infaunal deposit feeder (24%)
- *Nuculoidea* sp.
- *Nuculites oblongatus*

Reclining filter-feeder (16%)
- *Chonetes* sp.
- *Tropidoleptus carinatus*
- *Tentaculites* sp.
- *Mucrospirifer mucronatus*
- *Schuchertella* sp.
- *Pholidostrophia* sp.

Deeply buried endobyssate filter-feeder (16%)
- *Glossites* sp.
- *Modiella pygmaea*
- *Sphenotus* sp.
- *Nyassa arguta*
- *Modiomorpha* sp.

Epifaunal grazing herbivore (16%)
- *Bembexia sulcomarginata*
- *Palaeozygopleyra hamiltonae*
- *Holopea* sp.

Low-level rooted filter-feeder (11%)
- *Ambocoelia umbonata*
- *Pholidops hamiltonae*
- *Leiorhynchus laura*
- *Camarotoechia* sp.
- *Glyptodesma erectum*
- *Orbiculoidea* sp.
- *Athyris cora*

Epiplanktonic filter-feeder (4%)
- *Pterochaenia fragilis*

Epifaunal crawling or ploughing collector (4%)
- *Hyolithes* sp.
- *Phacops rana*
- *Greenops boothi*

Nektonic carnivore (3%)
- *Spyroceras* sp.
- *Orthocone* sp.
- *Goniatites* sp.

Deeply-fully buried filter-feeder (1%)
- *Lingula* sp.
- *Paracyclas* sp.
- *Lingulella* sp.

High-level attached filter-feeder (<1%)
- Crinoids
- Fenestellid bryozoan

Shallow-buried endobyssate filter-feeder (<1%)
- *Cornellites flabella*

plants. Small pelecypods were attached to floating or benthonic vegetation. Diversity is high as is dominance. The average number of species is 16.5, whereas the mean equitability is 0.80.

Throughout deposition of the Delphi Station with its Nuculoidea-Bembexia community, the waters shoaled while the average agitation increased. Eventually, the area was covered by siltstones and sandstones with the Actinopteria assemblage (Table 7) of the Pompey. The current-swept habitat was populated by a diversified suite of filter-feeding pelecypods distributed with moderate equitability and brachiopods that were able to tolerate variable conditions of agitation and rapid sedimentation. Filter-feeders make up 83 percent of the fauna; these animals exploited numerous different methods of filter feeding. The low amount of plant and animal organic matter present, perhaps acting in conjunction with high agitation and rapid sedimentation, is responsible for the small numbers of collectors, deposit feeders, and herbivores present (about 11 percent). During intervals of more winnowing and slow rates of deposition, "pioneer assemblages" of hardy solitary zaphrentid corals became established for one or several generations (Table 8). These were soon overwhelmed by rapid sedimentation and the seafloor was repopulated by the Actinopteria community.

The Leiorhynchus laura assemblage (Table 9) is characteristic of the Butternut although it occurs in the Mottville and Delphi Station. The Butternut shales and siltstones were deposited rapidly in poorly oxygenated and turbid water, often by turbidity currents; the seabed was extensively bioturbated. These stringent conditions dictated a low diversity fauna in which only the most tolerant filter-feeders could survive such as Leiorhynchus laura and Chonetes. Epiplanktonic molluscs and infaunal deposit feeders are also abundant.

During Centerfield and Otisco times, more favorable conditions developed due to decreased depth and rate of deposition along with higher amounts of dissolved oxygen. The shelf was invaded by the Mucrospirifer mucronatus assemblage (Table 10), a diversified fauna consisting mostly of filter-feeding brachiopods, such as M. mucronatus, Chonetes, and Tropidoleptus carinatus, and crinoids which make up almost 90 percent of the community. Conditions generally were similar to those that existed during the life and times of the Actinopteria assemblage except that the Mucrospirifer mucronatus occurred farther offshore in slightly deeper water where less sediment was accumulating. Owing to the more equitable environment, brachiopods were able to almost completely exclude pelecypods from the habitat.

The Staghorn Point beds of the Otisco constitutes a second interval where the seafloor was dominated by corals (Table 11). The colonial taxon Edriophyllum forms the base of the coral banks; this is succeeded by sediments with large solitary cystiphyllid and zaphrentid corals. As in the Pompey, the conditions that allowed the existence of the coral beds probably are reduced sedimentation rates and increased agitation.

The assemblages recognized here are definite numerical entities, albeit loosely structured ones. Numerous protean forms, such as Chonetes

Table 7. Faunal and ecological composition of Actinopteria assemblage.

Epifaunal reclining filter-feeder (29%)
Chonetes sp.
Productella spinulicosta
Tropidoleptus carinatus
Schuchertella sp.
Mucrospirifer mucronatus
Protoleptostrophia perplana
Atrypa reticularis
Tentaculites sp.
Deeply-buried endobyssate filter-feeder (17%)
Nyassa arguta
Modiomorpha sp.
Glossites sp.
Sphenotus sp.
Cimitaria sp.
Goniophora sp.
Macrodon sp.
Grammysia sp.
Shallow-buried endobyssate filter-feeder (17%)
Actinopteria sp.
Leiopteria sp.
Cornellites flabella
Low-level epifaunal rooted filter-feeder (16%)
Athyris cora
Mediospirifer audaculus
Leiorhynchus laura
Glyptodesma errectum
Pterinopecten sp.
Camarotoechia sp.
Ambocoelia umbonata
Infaunal deposit-feeder (7%)
Nuculoidea sp.
Nuculites oblongatus
Taonurus caudagalli
Palaeoneilo emarginata
Reclining carnivore (4%)
Cystiphyllum sp.
Zaphrentid
Aulopora sp.
High-level attached filter-feeder (3%)
Crinoids
Fenestellid bryozoan
Taeniopora sp.

Table 7. Continued.

Nektonic carnivore (3%)
- Spyroceras sp.
- Goniatite sp.
- Orthocone sp.

Epifaunal herbivore (3%)
- Bembexia sulcomarginata
- Ptomatis sp.
- Palaeozygopleura hamiltonae

Epifaunal ploughing and crawling collectors (2%)
- Greenops boothi
- Hyolithes sp.
- Phacops rana
- Dipleura dekayi

Epiplanktonic filter-feeder (<1%)
- Pterochaenia fragilis
- Buchiola sp.

Completely buried burrowing filter-feeder (>1%)
- Paracyclas sp.
- Cypricardella sp.
- Lingula sp.

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sp., Mucrospirifer mucronatus, Tropidoleptus carinatus, and Nuculoidea sp., occur in many of the assemblages. Probably chance and random larval settlement played a considerable role in the communities. Within fairly general limits, we suspect that stochastic processes could be used to model or simulate the variations with a community and perhaps to some extent between similar communities.

Some communities are dominated by one ecological niche, for example, the Tropidoleptus carinatus and Mucrospirifer mucronatus assemblages each have 64 percent reclining filter feeders. This situation is more exagerated in the samples dominated by Leiorhynchus limitare some of which may contain over 90 percent of pedicle-attached brachiopods. Ecological categories are more evenly distributed in the Nuculoidea-Bembexia, Actinopteria, and the equitable Leiorhynchus laura assemblages. For example, in the Nuculoidea-Bembexia assemblage, the first four ecological categories comprise 24.5, 16.4 and 15.9 percent of the fauna. The same figures for the Actinopteria community are 28.9, 17.5, 17.1, and 15.8 percent. Communities that are dominated by a single ecological niche also tend to be invested in one food resource. Filter feeders account for 74 and 94 percent of all the individuals in the Tropidoleptus carinatus and Mucrospirifer mucronatus assemblages. In the zaphrentid and Otisco coral faunas, 89 and 98 percent are concentrated in the carnivorous and normal filter-feeding roles.

Table 8. Faunal and ecological composition of Zaphrentid assemblage.

Reclining carnivore (59%)	
	Zaphrentid coral
Reclining filter-feeder (15%)	
	Chonetes sp.
	Mucrospirifer mucronatus
	Atrypa reticularis
	Productella spinulicosta
Deeply-buried endobyssate filter-feeder (11%)	
	Nyassa arguta
	Modiomorpha sp.
	Goniophora sp.
High-level attached filter-feeder (6%)	
	Bryozoa sp.
	Crinoids
Low-level rooted epifaunal filter-feeder (6%)	
	Mediospirifer audaculus
	Roemerella sp.
	Athyris cora
Shallow-buried endobyssate filter-feeders (2%)	
	Actinopteria sp.
	Cornellites flabella
Epifaunal browsing herbivore (1%)	
	Bembexia sulcomarginata
Nektonic carnivore (<1%)	
	Spyroceras sp.
Epifaunal crawling or ploughing collector (<1%)	
	Greenops boothi
Infaunal deposit-feeder (<1%)	
	Palaeoneilo emarginata

Table 9. Faunal and ecological distribution of species in Leiorhynchus laura assemblage.

Reclining - epifaunal filter-feeder (29%)
Chonetes sp.
Mucrospirifer sp.
Productella spinulicosta
Low-level rooted - epifaunal filterfeeder (28%)
Leiorhynchus laura
Ambocoelia umbonata
Epiplanktonic filter-feeder (27%)
Pterochaenia fragilis
Deeply buried endobyssate filter-feeder (8%)
Modiella pygmaea
Infaunal deposit-feeder (6%)
Nuculoidea sp.
Nektonic carnivore (1%)
Orthocone sp.
High-level rooted filter-feeder (<1%)
Crinoid

The more evenly distributed communities are not so limited in their adaptive strategires. Several different food resources are utilized by the Nuculoidea-Bembexia community of which the most abundant are filter-feeding 45 percent, deposit 24 percent, plant material 16 percent, small microorganisms and organic detritus on the surface 4.2 percent, and carnivorous 3.4 percent. On the other hand, numerous ecological categories are not correlated necessarily with different food materials. For example, in the Actinopteria community which has numerous ecological categories represented, 83 percent of the individuals are filter feeders. Here the diversity stems from different adaptations and strategires of filter feeding.

Table 10. Taxonomic and ecological composition of Mucrospirifer mucronatus assemblage.

Epifaunal reclining filter-feeder (64%)
- Chonetes sp.
- Mucrospirifer mucronatus
- Tropidoleptus carinatus
- Protoleptostrophia perplana
- Atrypa reticularis
- Productella spinulicosta

Low-level rooted epifaunal filter-feeder (16%)
- Camarotoechia sp.
- Athyris spiriferoides
- Mediospirifer audaculus
- Ambocoelia umbonata
- Pterinopecten sp.
- Roemerella sp.

High-level attached filter-feeder (12%)
- Crinoids
- Fenestellid bryozoan
- Taeniopora sp.

Infaunal deposit-feeder (4%)
- Nuculoidea sp.
- Nuculites oblongatus
- Palaeoneilo emarginata
- Taonurus caudagalli

Shallow-buried endobyssate filter-feeder (1%)
- Leiopteria sp.
- Actinopteria sp.

Deeply-buried endobyssate filter feeders (1%)
- Goniophora sp.
- Modiomorpha sp.
- Nyassa arguta
- Sphenotus sp.

Epifaunal ploughing and crawling collectors (1%)
- Greenops boothi
- Phacops rana

Nektonic carnivore (<1%)
- Orthocone sp.
- Goniatite sp.

Completely-buried burrowing filter-feeder (<1%)
- Paracyclas sp.
- Cypricardella sp.
- Lingula sp.

Table 11. Faunal and ecological composition of solitary coral assemblage of Staghorn Point.

Reclining carnivore (61%)
- Cystiphyllum sp.
- Unidentified large zaphrentid
- Edriophyllum sp.
- Favosites sp.

Reclining filter-feeder (36%)
- Chonetes sp.
- Mucrospirifer mucronatus
- Atrypa reticularis
- Tropidoleptus carinatus

Low-level epifaunal rooted filter-feeder (2%)
- Mediospirifer audaculus

High-level attached filter-feeder (17%)
- Crinoid

Infaunal deposit-feeder (<1%)
- Palaeoneilo emarginata

Deep-level endobyssate filter-feeder (<1%)
- Goniophora sp.

Epifaunal crawling or ploughing collector (<1%)
- Phacops rana

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ROAD LOG

Paleoecology and Stratigraphy of the Lower Hamilton Group in the Syracuse Area

(The stratigraphic descriptions of stops 1-3, and 5-8 are from Chute and Brower, 1964).

0.0	Syracuse University Field House at corner of Colvin St. & Comstock Ave. Proceed W on Colvin St.
0.8	Turn left (S) on State St.
3.5	Continue S to entrance ramp of I81.
5.2	Exit from I81 at exit 16 (Nedrow)
5.5	Turn left (SE) on Rt NY11
5.7	Turn left (E) on access road to Kennedy Rd.
-	Park just beyond culvert
-	STOP 1: Top of the Onondaga Limestone and basal Union Springs Shale displaced by a small thrust fault.

The upper 8 ft of the Onondaga Limestone and about 10 ft of the Union Springs Shale are exposed on the side of the deep drainage ditch on the east side of the road. Exposures of the top contact of the Onondaga such as this are rare.

The Union Springs is the basal member of the Marcellus Formation. The three pelagic assemblages characterized by *Styliolina fissurella*, *Pterochaenia fragilis*, and *Leiorhyncus limitare* occur in the Union Springs.

At the south end of the drainage ditch a thrust fault with a throw of about 5 ft cuts the top of the Onondaga but is absorbed in the Union Springs Shale above by complex crumpling and jointing.

5.8	Turn right (S) on Kennedy Rd.
6.4	Turn left (E) on Bull Hill Rd.
7.4	Intersection with Sentinal Heights Rd.
8.4	Turn left (N) on LaFayette.
9.1	Turn right (E) on Coye Rd.
9.7	Stay left (N) at intersection with Eager Rd.

10.8 Intersection with Gordon Cooper Dr.

11.0 Intersection with Roberts Rd.

11.3 Turn left (N) on Apulia Rd.

12.1 Turn right (E) on Seneca Turnpike (Rt NY173).

12.2 Intersection with Solvay Rd.

12.5 Onondaga County Penitentiary constructed of the Edgecliff Member of the Onondaga Limestone on right (S).

12.8 Intersection with Taylor Rd.

13.5 Turn right (S) on Gates Rd.

\- STOP 2: Chittenango and Cardiff shales.

The Chittenango and Cardiff Members of the Marcellus Formation are exposed at this stop. Both are sparsely fossiliferous, but representatives of the wood assemblage and the *Leiorhynchus* assemblage as well as scattered fish scales and pyritized cephalopod shells occur.

This shale is quarried by the Alpha Portland Cement Company for use in cement manufacture at its Jamesville plant. Although these shales are similar in appearance, they can be distinguished easily by their streaks. The Chittenango Shale, because of its relatively high content of carbonaceous matter, streaks brown when scraped by a hard object such as a geologic hammer, whereas the Cardiff streaks light gray. Examination of drill core from several test holes has shown that the change in color of the streak takes place within a vertical interval of 3 ft. The contact is placed where, in going downward, the streak becomes distinctly brown. Located in this manner, the contact is near the top of the lower face, 5 to 6 ft above the upper layer of large septarian concretions.

Many of the septarian concretions in the upper part of the Chittenango are several ft across. The Cardiff shale on the other hand has only a few concretions and these are seldom more than 6 inches in diameter. The cracks within the septarian concretions commonly contain calcite, ferroan dolomite, and white, platy barite. Small crystals of barite with some pyrite also coat joint surfaces in the shale in places.

Return (N) on Gates Road.

14.4 Turn right (E) on Seneca Turnpike (Rt NY173).

15.0 View of Allied Chemical Corp., Solvay Process Division Quarry on left (S).