SEDIMENTOLOGY AND FAUNAL ASSEMBLAGES IN THE HAMILTON GROUP OF CENTRAL NEW YORK

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INTRODUCTION

The Middle Devonian (Givetian) Hamilton Group in Central New York State consists of approximately 1600 ft. (approximately 490 meters) of richly fossiliferous interbedded shales, siltstones and sandstones. During Givetian time, the central New York region lay to the west (present geography) of the Appalachian mobile belt. The sediments derived from this orogen were transported to the west and northwest into an epicratonic foreland basin. Other studies (Brett et al., 1983; Baird, 1979) suggest that deposition in western New York took place on a topographically subdued bottom. Regionally, paleoslope was SW-directed, but local swells and depressions of 20-100 km wave length were present (Baird, 1979). In the region of this study, the Hamilton has been the subject of numerous paleontological studies, from the pioneering work of James Hall through the biostratigraphic studies of Cooper (1930, 1933). More recently, the integration of paleontological data and detailed sedimentologic/stratigraphic studies have resulted in the development of depositional/paleoecological models (e.g. Brett et al., 1983). The purpose of this trip is to introduce participants to the varied faunas and lithofacies of the Hamilton and to document the cyclic arrangement of faunas and facies. It is this cyclicity that provides us with a key to understanding the sedimentological evolution of the Hamilton Group.

Fig. 1. Location map of study area. Stippled pattern illustrates distribution of marine (Hamilton Group) Givetian rocks in New York.

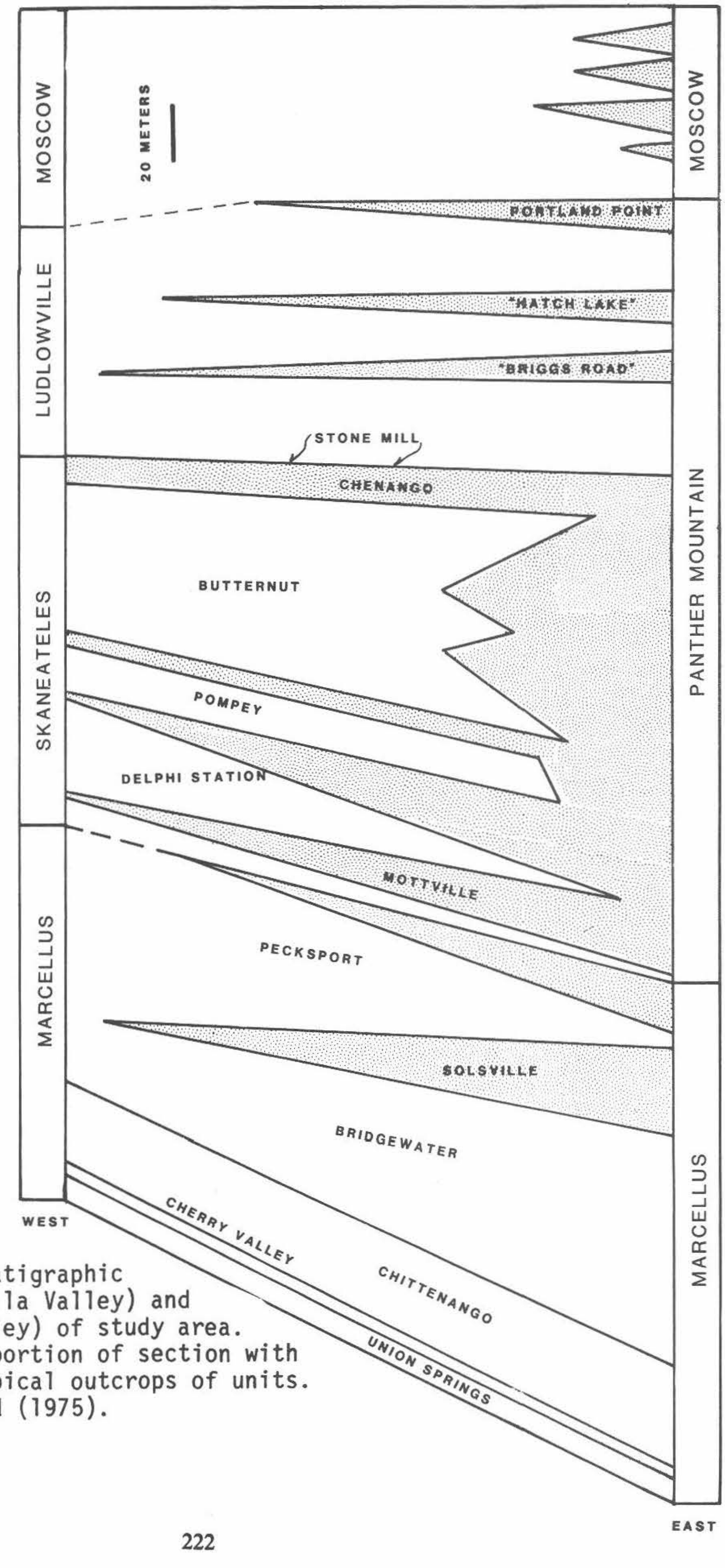

Fig. 2. Schematic lithostratigraphic section east (approx. Unadilla Valley) and west (approx. Cazenovia Valley) of study area. Stippled pattern indicates portion of section with greater than 50% sand in typical outcrops of units. Thicknesses based on Rickard (1975).

STRATIGRAPHY

The stratigraphy developed by Cooper (1930, 1933), and modified by Rickard (1975) is presented in Figure 2. The subdivision of the Hamilton Group in the region of this study was developed by Cooper in west-central New York, where a number of thin limestones provide lithologically prominent units that serve as formation-level boundaries. Correlation of these limestones with laterally equivalent thin limestones, shell beds and sandstones permitted Cooper to carry a four-fold subdivision of the Hamilton Group to the east, through the area cf the Chenango Valley. Loss of key horizons and rapid facies changes prevented Cooper from successfully carrying this four-fold subdivision beyond the Unadilla Valley (approx. 50 kms to the east of the area of this study).

The basal Chittenango Member of the Marcellus Formation rests atop the underlying Seneca Member of the Onondaga Limestone. Rickard (1975) has documented the regionally diachronous character (youngest in western N.Y.S.) of this contact. Locally, the contact is quite sharp, with interbedded calcareous shales and thin, dark limestones occurring immediately above the contact. The Cherry Valley Limestone Member of the Marcellus, possessing an abundant benthic fauna, separates the poorly fossiliferous Chittenango Member from the dark, poorly fossiliferous Union Springs silty shale.

The remainder of the Hamilton Group, including that portion of the Marcellus above the Union Springs shale, the Skaneateles, the Ludlowville and Moscow Formations, is characterized by rather regular, cyclic arrangement of lithologies, sedimentary structures and accompanying fauna. This existence of this cyclicity is immediately evident on simple inspection of the stratigraphic column in Figure 2. Beginning with the silty shales of the Bridgewater Member, a regular repetition of silty shales and sandstones recurs throughout the Hamilton Group. These include the Bridgewater-Solsville; Pecksport-Mottville; Delphi Station; Pompey; Butternut-Chenango plus Stone Mill; two (unnamed) shale-sandstone cycles in the Ludlowville; upper Ludlowville-Portland Point; plus at least 4 cycles in the Moscow Formation. These alternating silty shale, siltstone, and sandstone units form the basis of the member-level subdivisions of the Hamilton by Cooper. Within these major silty shale-sandstone cycles, smaller-scale "subcycles" are recognizable.

The internal stratigraphy of many of the Hamilton Group cycles in the study area consists of basal dark, grey fissile silty shales with low faunal diversity, grading upward into coarser-grained shaley siltstones with abundant marine fauna, followed by fine-grained silty sandstones possessing a somewhat lower faunal diversity. The sandstone units exhibit a variety of current and/or wave formed primary structures. Internally, the sandstone units often coarsen upward and contain pronounced internal scour surfaces marked by thin shell concentrations. In some instances, the coarsest sandstone of a cycle is capped by thin limestones and/or shell-rich units (e.g. Chenango-Stone Mill; Upper Ludlowville-Portland Point). These sandstone units, with associated bioclastic grainstones, are regionally correlative with limestone units in west-central New York State, and record conditions that were boradly contemporaneous

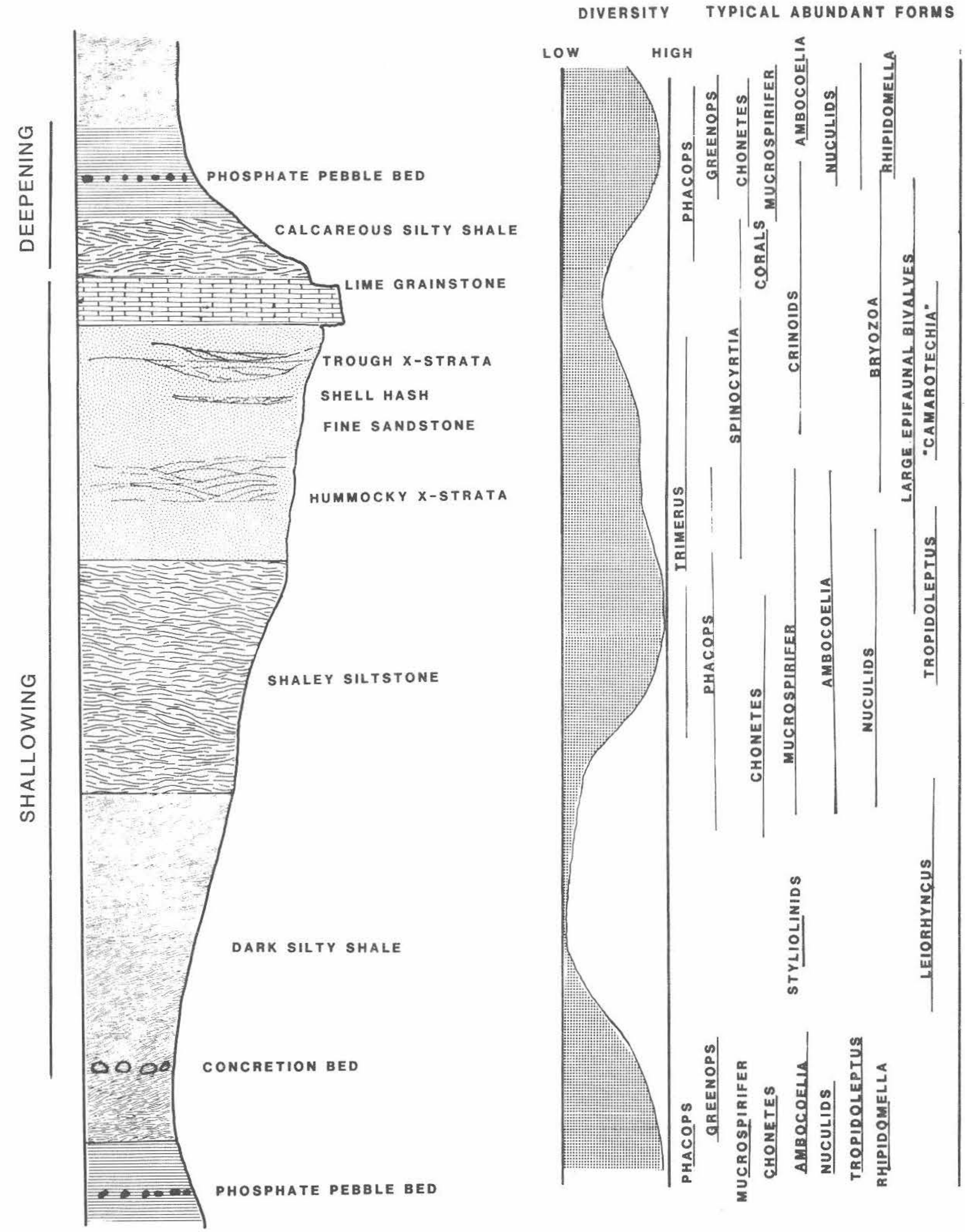

Fig. 3. Idealized Hamilton Group Cycle illustrating arrangement of various lithofacies and faunal elements. Note that many of the features shown are not present in all cycles. Vertical scale is variable.

on a basinal scale. Above the sandstones (or overlying bioclastic grainstone), finer-grained facies appear. Calcareous shaly siltstones with a relatively diverse fauna give way to finer silty shales, followed in some portions of the section by dark silty shales with a more limited fauna. Phosphate pebble beds commonly occur in the silty shales overlying sandstone units. The phosphate pebble beds exhibit considerable lateral continuity.

On a regional scale, some sandstone units can be traced west to the Skaneateles Valley (approx. 100 kms west of the study area). To the east, sandstone units merge into sandstone-dominated facies east of the Cooperstown Valley (approx. 75 kms east of the Chenango Valley) as intervening finer-grained silty shales become subordinate. The stratigraphic system that emerges, is one of sandstone "units" extending to the west within otherwise mudrock-dominated facies. Further, the sandstone units of the Central New York area are in part stratigraphically equivalent to the thin limestones that form the stratigraphic framework of the western N.Y. Hamilton Group. The cycles identified within the Hamilton Group of Central New York are asymmetric, in that if the coarsest sandstone units or bioclastic grainstones are considered the "core" of each cycle, the overlying "fining upward" portion is considerably thinner than the succeeding "coarsening upward" section. Further, it is clear that the cycles reflect alternating "shallower" and "deeper" water depositional conditions.

Internal Features of the Hamilton Group Asymmetric Cycles

For the purpose of discussion, the Hamilton Group cycles can be subdivided into 5 major facies types (Figure 3): basal dark silty shales; shaley siltstones; silty sandstones; bioclastic grainstones (often absent) and calcareous silty shales. While a particular cycle may not exhibit each facies component and many subtle vertical alterations of facies exist, outcrop-scale variations usually permit resolution of position within a larger cycle.

Basal dark silty shales:

Common attributes of this facies include low faunal diversity, general lack of current-formed primary structures and relatively high organic contact. General bioturbation is often present, but difficult to observe due to compaction. Pyritized burrows and fossil fragments are common. The typical fauna consists of *Leiorhyncus* sp. (common), styliolinids (especially in Marcellus Formation), *Ambocoelia* (near contact with overlying silty shale facies), plus rare *Chonetes*, *Paleozygopleura*, *Greenops*, *Tornoceras*, *Spyroceras* nuculids and plant fragments. Quantitative measures of both diversity and equitability indicate a stressed environment. The high organic content of this facies suggests low oxygen levels on the substrate, and oxygen availability was likely a diversity-limiting factor. Thin ripple-laminated siltstones are often present in this facies, and may document local- to regional-scale storm-related turbidite events. Concretions, often containing authigenic metallic sulfides, barite, celestite and dolomite in Septarian fractures, document pre-compaction cementation in this facies.

Shaley siltstones:

This facies consists of grey to brown crumbly to blocky weathering, slightly calcareous shaley siltstones, which exhibit upsection increase in faunal diversity within a given cycle. The basal portion of this facies contains a low to moderate diversity fauna dominated by Ambocoelia, Chonetes, nuculid bivalves, and Mucrospirifer. Greenops is typically present, but is replaced in relative abundance by Phacops in coarser variants of this facies. As the overlying sandstone facies is approached, faunal diversity rapidly increases, particularly through the addition of the larger brachiopods (Spinocyrtia, Tropidoleptus) semi-infaunal bivalves, bryozoans, and crinoids. The highest diversity and equitability is found near the siltstone-sandstone transition. Thin shell-rich horizons are common in this facies, but are often masked by subsequent bioturbation. Evidence of traction current reworking is limited to shell beds and rare ripple-laminated beds.

Silty sandstones:

The fine-grained silty sandstone units exhibit abundant current-formed-primary structures including ripple cross-lamination, hummocky-cross stratification, trough cross-stratification, symmetrical and asymmetrical ripples and internal scour surfaces floored by shell debris. The fauna consists of the larger brachiopods and bivalves, plus bryozoans and crinoids. Horizontal and vertical burrows and feeding traces are common, but complete bioturbation is rare.

Soft-sediment deformation (pillow structures, "flow rolls") are present in some sandstone units, and indicate the re-adjustment of sands rapidly deposited over watery muds. Rip-up clasts of mud-rich lithologies are common.

Faunal diversity is considerably lower in the sandstones than in underlying shaley siltstones, but equitability remains high.

Bioclastic grainstones:

This lithology is comparatively rare in the section, but is critical to interpretation of Hamilton Group cycles. Typically the grainstones occur as laterally discontinuous lenses consisting of abraded shell debris. Crinoid plates and brachiopod and bivalve fragments set in a matrix of medium-grained sand is the dominant lithology. Clast of cemented limestone and rare phosphate pebbles and shale clasts are also present. In one instance (Stone Mill Member) the top portion of the limestone contains an "in situ" fauna with abundant rugose and favositid corals and bryozoans. Because of the fragmental nature of the fossil material and the clearly transported nature of the assemblage, faunal diversity and equitability have not been determined.

Calcareous silty shales:

Rather abruptly overlying the sandstone or bioclastic grainstones are grey, calcareous silty shales. This facies exhibits increased faunal diversity and equitability compared to the underlying sandstones, and is dominated by large brachiopods, bivalves and bryozoans. Thin (2-15 cms) phosphate pebble beds are common, usually occurring as a single, laterally continuous bed. The phosphate pebble beds consist of a mixture of broken and whole shells, 0.5 - 1.0 cm subrounded phosphate pebbles, phosphatic steinkerns of trilobites and brachiopods and phosphatic fish plates that form a distinctive resistant pavement in quarry exposures. These beds clearly record periods of very limited clastic sediment input and lengthy exposure of the sediment-water interface to early diagenetic and chemical processes. The abraded shell material and rounded phosphatic clasts indicate at least sporadic traction current activity. The dominant faunal elements of the calcareous silty shales are similar to those found in the shaley siltstone facies of Hamilton Group cycles, reflective of similarity of environmental conditions.

Detailed discussion of particularly significant faunal elements and sedimentological/early diagenetic features are included in stop descriptions.

ENVIRONMENTS OF DEPOSITION

The asymmetric cycles in the Hamilton Group record deposition of terrigenous clastic sands and muds under conditions of varying water depth, wave and current reworking of the bottom, oxygen levels and substrate stability. Regional facies patterns and local vertical facies changes suggest that the Hamilton Group of the study area is not a product of "classic" deltaic deposition. Paleocurrent directions and regional facies patterns indicate that the clastics were derived from a tectonic source land to the present southeast, yet the cyclic sedimentation pattern does not appear to result from simple progradation of deltaic facies onto a marine platform. External eustatic sea-level fluctuations appear to better explain both vertical facies patterns and the temporal correlation of sandstones in central New York with thin limestones to the west. We suggest that each shale-siltstone-sandstone-shale cycle is the product of relatively rapid sea level rise, followed by deposition under relatively stable sea-level conditions. The dark silty shales which the base of each cycle were deposited during periods of maximum water depth, minimum reworking of the bottom by waves and currents and input of mud by suspended load deposition. With continued deposition, perhaps accompanied by slight sea level fall, water depths shallowed to first permit better agitation of bottom waters and colonization of the substrate by progressively more diverse marine faunas. With continued shallowing, influx of traction load sands and the production of hummocky cross-stratification, scour and fill, ripple lamination occurred as waves and currents influenced the bottom. Maximum shallowing is represented by the coarsest sandstones and/or bioclastic grainstones present in the cycles. Relatively rapid sea level rise following deposition of these facies resulted in diminished input of coarse terrigenous clastics and renewed deposition of muds inhabited by a diverse marine fauna. Phosphate pebble beds record virtual cessation of clastic input as rapid sea-level rise occurred. The eventual recurrence of dark silty shales marks the maximum deepening prior to the next upward shallowing depositional phase.

This model then suggests that the thin bioclastic limestones (e.g. Stone Mill Member, Portland Point) are the shallowest-water facies present in the section. This proposal stands in sharp contrast to the conclusions of McCave (1973), who suggested that the limestones are the products of deposition following maximum shallowing, when clastic input had been terminated by drowning of deltaic distributaries to the east. Our model correlates limestone deposition with maximum shallowing, when shell material was concentrated by wave and current winnowing of finer terrigenous clastic muds and sands. Rapid deepening, and drowning of sediment input systems correlates with the very low clastic depositional rates indicated by phosphate pebble beds and shell-rich horizons. Periods of maximum water depth are recorded by dark, silty shales with lower faunal diversity.

The suite of primary structures and the abundance of shell-lag horizons in sandstone units strongly suggest that the dominant bottom-current effects were storm related. Although tide-dominated facies have been recognized in the Hamilton Group to the east of the study area, evidence for tidal current effects in this area are absent. Storm-generated waves and bottom currents were responsible for the seaward transport of muds and sands from coastal areas to the east, the generation shell lag concentrations, hummocky cross-stratification (Bourgeois, 1980) and may have been responsible for the turbidite-like laminated siltstones found sporadically in the otherwise finer-grained, deeper water facies.

RATES OF DEPOSITION

At least 13 major asymmetric cycles can be identified in the Hamilton Group in central New York. Assuming that the Givetian deposition spanned approximately 7 million years, the duration of each major cycle was approximately 7 million years, the duration of each major cycle was approximately 500,000 years. This period is consistent with the estimated duration of sea-level oscillations identified elsewhere in the Mid-Paleozoic of the Appalachian Basin (e.g. Dennison and Head, 1975). Smaller-scale sea-level oscillations are superimposed on these longer periods of fluctuations.

The average depositional rate of the Hamilton Group is approximately 70 meters/10^6 years or less than 0.1 mm/year. This rate is considerably lower than that calculated for the subsidence rate (= long term probable net deposition) of modern sedimentary basins, which varies from 0.3-2.5 mm/year. This data indicates that Hamilton Group deposition took place upon a relatively stable cratonic basement, and thus, the subsidence behavior of the basin more nearly resembled the "tectonic quiesence" of the Late Silurian and early Devonian, characterized by deposition of platform carbonates, than the crustal instability and rapid basin subsidence evident in the late Devonian and Carboniferous history of the Appalachian Basin.

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ROAD LOG - Hamilton Group
Robert Linsley and Bruce Selleck

Note: The road log begins at the intersection of N.Y.S. Route 46 and Pratt Road, approximately 1.5 miles south of the Village of Munnsville. From Clinton, proceed south on N.Y.S. Rt. 12B, through Deansboro and Oriskany Falls to U.S. Rt. 20. Then west on Rt. 20 to Pine Woods, then north on N.Y.S. Rt. 46 to begin road log. Mileage to nearest 0.05 odometer miles.

Cum. Miles	Comments
0.0	Intersection of N.Y.S. Rt. 46 and Pratt Road. Proceed south on Pratt Road. Low hills in center of valley are part of the Munnsville kame-moraine complex. On the eastern valley wall, an active limestone quarry in the Helderberg Group and Lower Onondaga Limestone is visible.
0.55	Turn right (west) onto Stockbridge Falls Road.
1.50	Outcrops of Upper Helderberg Group and basal Onondaga Limestone (Edgecliff Member) on right.
1.80	Outcrop of Seneca Member on right.
2.25	Outcrops of Cherry Valley Limestone on right.
2.75	**Stop #1** - Upper portion of Chittenango Shale-Member of Marcellus Formation - Roadcut on left.

Stratigraphy/Sedimentology

This roadcut exposes a typical section of the black silty shales that dominate the lower Marcellus Formation. Fissile, organic-rich silty shales record deposition on an anaerobic/dysaerobic marine substrate. The extreme limitation of oxygenation and bottom circulation during deposition of this facies suggests that the waters of the basin may have been stratified in a manner analogous to the modern Black Sea. Large carbonate-cemented concretions are well-exposed mid-way up the outcrop face, and cearly demonstrate that pre-compaction cementation occurred. Note that the laminae in the silty shales are deformed by compaction around the concretions. Septarian fractures in the concretions have yielded finely crystalline dolomite, calcite and barite. Note that the surfaces of some concretions appear to have preserved burrows and steinkerns of gastropods. Is there a linkage between the presence of the burrows/fossils and the formation of the concretions?

Fauna

The fauna at this stop is exceedingly limited, dominated by Styliolina with occasional specimens of Nowakia, Leiorhychus and "Euryzone". The styliolinids and Nowakia occur abundantly on particular bedding planes that occur sporadically throughout the section. It is presumed that these are planktonic forms for they are occasionally found in almost all of the lithologies of the Hamilton Group, including the apparently inhospitable environment suggested by these non-bioturbated black shales. It has recently been persuasively argued (Yochelson, in press) that Styliolina is not a mollusk, and although he did not assign it to any other higher taxon, we are persuaded that it is safest to assume that it is not a member of an extant phylum, and Fisher's assignment to the Cricocondarida seems as sound as any. Nowakia occurs much more rarely (about 1% of the fauna), but is found with the styliolines and presumably shares a similar mode of life even though taxonomically it is a tentaculitid rather than a styliolinid.

Leiorhychus and "Euryzone" are not usually found in association on the same bedding plane as Styliolina, but scattered throughout the section. Two very different interpretations have been placed on the paleoecology of these genera. It has been suggested that "Euryzone" could have had a mode of life similar to the extant genus Ianthina, which builds a bubble raft to which it clings until it bumps into its prey, the Portuguese Man-of-War, Porcellia. It has similarly been suggested that perhaps Leiorhychus was attached by its pedicle to floating pieces of wood. These interpretations thus attribute the occurrence of these genera to being introduced from outside the immediate environment. However, since both species are restricted to the black shale environment of the Hamilton we suspect that they are indeed adapted to maintaining a marginal existence in an environment that is an abomination to other faunal elements.

(Note: we have placed quotation marks around "Euryzone" because we have never seen a specimen that was determinable below the ordinal level of Archaeogastropoda. Other members of the genus Euryzone are associated with reef deposits and the anomalous environment of the Hamilton form suggests that it is probably not appropriately assigned to this genus.)

Cum. Miles	Comments
2.75	Continue west on Stockbridge Falls Road
3.45	Turn left (west) onto unnamed road
4.90	Turn left (south) onto Glass Factory Road
5.45	Cross Oneida Creek
6.10	Turn right (west) onto Fearon Road
6.45	Turn left (south) onto Swamp Road
6.90	**Stop #2** - Bridgewater and Solsville Members of Marcellus Formation.

The basal section of the exposure here consists of dark, fissile to blocky silty shales which bear a rather limited fauna. The section coarsens upward, corresponding with gradual increase in faunal diversity. The basal portion of the Solsville Member is difficult to access at this stop, but a fair selection of typical Solsville forms can be found in talus mid-way up the exposure.

The preservation of the fossils at this locality is quite exceptional. Thin sections of the material shows that growth lines are well preserved, suggesting that the calcitic shells preserved here are probably original material. Some aragonite is still preserved, but most has been altered to calcite. Still even the mollusks exhibit good growth lines which suggests that the replacement of aragonite is a very precise molecule for molecule substitution.

This unit is also the site of some rather rare and unusual fossils including the monoplacophoran Cyrtolites and the bellerophont Praematarotropis and soft bodied preservation of annelids (Cameron, 1967).

The fauna is dominated by the brachiopods Spinocyrtia in the upper sandier facies, and Mucrospirifer in the middle siltier layers, along with the bivalves, Ptychopteria flabellum, Gosseletia triquetra, and a variety of nuculids, gastropods including Bembexia sulcomarginata and Palaeozygopleura hamiltoniae plus a variety of orthoconic cephalopods.

One unusual aspect of the preservation in this quarry is the fact that a very large percentage of the bivalves are preserved with both valves intact. This is no surprise for nuculids which are infaunal and typically are entombed in the sediments which prevents their valves from gaping open upon death. However, for bysally attached semi-infaunal forms like Gosseletia, mobile semi-infaunal forms like Grammysia and epifaunal genera like Ptychopteria, it is unexpected to find both valves intact. It would seem possible that quick burial may have been an intermittant, but relatively common cause of death in this assemblage. This interpretation is also consistent with the rather large escape burrows that are abundant in this unit.

Many faunal elements in this unit are restricted to single bedding planes that may repeat throughout the quarry. For example, Palaeozygopleura has been found on only three horizons, but within those horizons they may be very abundant. The axis of coiling of the shells of Palaeozygopleura in this quarry are randomly oriented allowing us to infer that they have not been aligned by current action. Yet twice as many are found in an aperture down position as in an aperture up position. Since all positions of this shell exhibit equal hydrodynamic stability, we infer that the shells were occupied at the time of death, and the orientation of the shells reflects the life position.

Other bedding planes are dominated by Bembexia sulcomarginata, a pleurotomarian which was probably an algae grazer or possibly a deposit feeder. Many of the shells of Bembexia in this unit are encrusted with a trepostomatous bryozoan (Leptotrypella). Most frequently it is the upper surface of Bembexia that is encrusted, though some specimens exhibit encrustation of the base while the spire remains clean. Very rarely is a specimen found in which the encrustation spreads very far from one side onto the other. We suspect that encrustation primarily developed on dead shells on Bembexia. Bembexia is a genus that is only found in the Marcellus and Skaneateles Formations of the Hamilton Group while Palaeozygopleura is found throughout.

Cum. Miles	**Comments**
6.90	Continue south on Swamp Road
9.60	Intersection with U.S. Rt. 20 in Village of Morrisville; turn left (east) then immediately right (south) onto River Road.
13.70	Turn right onto N.Y.S. Rt. 26 in Eaton, N.Y.
15.00	Turn left (south) onto Bradley Brook Road
17.40	Turn right (west) onto Soule Road
17.45	**Stop #3** - Quarry entrance on left. Park on side of road. Basal Moscow Formation.

Stop #3. This quarry exposes the "interior portion" of an upward-coarsening cycle of the Hamilton Group and can be generalized as consisting of an upper sandy facies dominated by bivalves and a lower silty facies dominated by brachiopods. Separating the two facies is a thin coquina consisting predominantly of the shells of Spinocyrtia granulosa.

The upper sandy unit is dominated by large epi-byssate bivalves and large semi-infaunal bivalves as well as larger spiriferoid brachiopods. There are also occasional specimens of the burrowing trilobite Trimerus (Dipleura) deKayi and large specimens of Phacops rana.

The lower silty portion of dominated by brachiopods, particularly Chonetes, Devonochonetes, Athyris Rhipidomella, and Mucrospirifer. Bivalves are also abundant, commonly infaunal nuculids or mobile semi-infaunal forms (such as Grammysia). The dominant trilobites in this facies are Greenops and smaller specimens of Phacops. Gastropods are represented by Glyptotomaria and Ruedemannia, the bellerophont Retispira and Palaeozygopleura. Bembexia drops out of the fauna after the Skaneateles. However, the Palaeozygopleura shells in this quarry are barely recognizable for the shells are completely encrusted by the trepostomate bryozoan Leptotrypella. The aperture is always open, but the shell is completely encursted all the way around which is quite surprising since Palaeozygopleura is a shell dragger, incapable of lifting its shell from the substrate. This leads us to conclude that either Leptotrypella was capable of extending its colony down into the sediment (which no modern bryozoan can do) or that there was a secondary occupant (a sipinculid?) of the dead Palaeozygopleura shell that was capable of elevating the shell off of the substrate so that the bryozoan could establish itself everywhere except the aperture. In some individuals the encrustations became much thicker on one side of the shell than the other, always the adapertural side is thickened, which leads us to believe that the secondary occupant is still occupying the shell, but the mass of bryozoans has forced him to resort to a shell dragging mode, thus killing the bryozoans on the apertural side of the colony.

There are also massive colonies of other trepostomatous bryozoans in the lower part of the quarry.

Cum. Miles	**Comments**
17.45	Turn around, head east on Soule Road
17.50	Turn right (south) onto Bradley Brook Road
18.40	Turn left (east) onto Geer Road
19.20	**Stop #4** - Geer Road - Quarry entrance on left. Park on side of road. Basal portion of Moscow Formation.

Stop #4. Stratigraphically and faunally this locality is similar to Stop #3. The faunal elements are essentially as described for the previous locality. Some of the rarer elements of the fauna of both quarries include Hyolithes, occasionally with helens and operculum in place, and two different phyllocarids with their bivalved cephalothorax and segmented abdomen with the telson composed of three spike-like projections.

A prominent surface near the basal portion of the section exposes a phosphate pebble bed containing abundant brachiopods and rare fish plates.

Cum. Miles	**Comments**
19.20	Continue east on Geer Road
20.10	Intersection with Kenyon Road. Continue east on Geer Road.
20.80	Intersection with Lebanon Reservoir Road. Turn left (east).
22.80	Intersection with River Road. Proceed across River Road onto Armstrong Road.
23.80	Intersection with Lebanon Street - turn left (N).
26.80	Main Street light - Village of Hamilton, intersection with N.Y.S. Route 12B.
27.00	Turn left (E) onto E. Kendrick Avenue - Pass entrance to Colgate University
27.20	Turn right (E) onto Hamilton Street. Colgate campus on right.
29.75	Bear left at "y" intersection
30.40	Turn left (N) onto Poolville Road.
32.10	Hamlet of Hubbardsville; continue north through intersection onto Quarterline Road.
32.90	Turn right (E) onto Rhodes Road.
33.50	Turn left (N) onto Cole Street (becomes Cole Hill Road).
35.40	**Stop #5** - Roadside Quarry and rubble: Mottville Member of Skaneateles Formation:

Sedimentology:

The exposure at this stop nicely exhibits the shaley siltstone-to-sandstone transition of the Mottville Member. The lowermost portion of the outcrop consists of relatively fissile to blocky shaley siltstones dominated by small brachiopods. The section coarsens rapidly upward to silty, fine-grained sandstones which exhibit some cross-lamination and rare hummocky bedding.

Fauna

This stop is dominated by the higher energy faunal elements that characterize the silty sandstones of the Hamilton Group. These include the large epifaunal byssate pectinoid bivalves including Glyptodesma, Leiopteria, Pterinopecten, Actinopteria and Limoptera as well as semi-infaunal bivalves such as Grammysia. The typical trilobite of the unit is the large burrowing trilobite Trimerus, whose punctate carapace comprises one of the dominant skeletal elements of this locality. Complete specimens are fairly common, most commonly not enrolled and not infrequently oriented on edge or on end as some other unusual position relative to the sediments. It is suggestive that the area was occasionally subjected to events, which involved rapid burial. Other common elements include the brachiopods Spinocyrtia, Mucrospirifer, Camarotoechia and Devonoproductus. The gastropods are not well preserved here, but include Bembexia and Palaeozygopleura.

End of Trip (To return to Clinton, N.Y. proceed north on Cole Hill Road to intersection with Pleasant Valley Road (approx. 1 mile). Turn left (N) onto Pleasant Valley Road. Proceed north to intersection with U.S. 20. Turn left (W) onto U.S. 20. Proceed on U.S. 20 to intersection with N.Y.S. Rt. 12B. Turn right (N) onto N.Y.S. 12B and proceed north to Clinton.)