Trip A-4

RE-EXAMINATION OF THE TYPE ITHACA FORMATION: CORRELATIONS WITH SECTIONS IN WESTERN NEW YORK

JAMES J. ZAMBITO IV
University of Cincinnati, Department of Geology, 500 Geology/Physics Building, Cincinnati, OH, 45221-0013
e-mail: zambitjj@uc.edu

GORDON C. BAIRD
SUNY College at Fredonia, Department of Geosciences, Fredonia, NY 14063

CARLTON E. BRETT
University of Cincinnati, Department of Geology, 500 Geology/Physics Building, Cincinnati, OH, 45221-0013

ALEX J. BARTHOLOMEW
SUNY New Paltz, 1 Hawk Dr, Wooster Science Bldg, New Paltz, NY 12561

INTRODUCTION

Stratigraphic correlation of the early Frasnian (Genesee Group) in New York has been ongoing for over 150 years (see Kirchgasser 1985 and Kirchgasser et al. 1994 for summary). While recent work has recognized key temporal horizons (e.g., sequence boundaries, condensed sections, and flooding surfaces) in western New York sections, correlation of such horizons into the vicinity of Ithaca, New York is currently ongoing (Kirchgasser 2000, Baird et al. 2006). This study focuses on detailed re-examination of the Ithaca Formation of east-central New York in its type area, which has not been studied in any detail since the early 1980's (see Kirchgasser 1985). We use sequence stratigraphic approach to describe and correlate these strata; a model which was previously unavailable to past researchers. Herein we summarize progress in characterizing small-scale sedimentary cycles within the Ithaca Formation, as well as the identification of horizons and/or beds that may be correlative with those previously recognized in western New York sections. We present a working hypothesis of high-resolution correlation within the Ithaca Formation. These include fossil-rich calcareous siltstone and shell-rich limestone beds that appear to record sediment starved intervals associated with both small- and large-scale transgressions. The latter may at least correlate with condensed, styliolinid-rich pelagic limestones in western New York.

Given that certain Genesee divisional units recognized in western New York (Schumacher Bed of the Penn Yan Formation, Genundewa Formation, "Huddle Bed" of conodonts and *Styliolina* in the basal West River Formation) have not yet been correlated with any certainty into the Ithaca region, and, given that certain Ithaca area units (Renwick Formation, Beebe Limestone, Williams Brook Limestone, as well as some newly described condensed intervals in the lower Ithaca Formation) have not been confidently linked into the stable stratigraphic succession of the Genesee Valley-Erie County region, the results presented here are a "work in progress". By establishing a "cat's cradle" of bed-to-bed matches between the various, large Ithaca gorge sections, we will be able to construct a hierarchy of units and beds that reflect eustatic changes and important bioevents. This linkage of local sections will also allow us to out-correlate marker beds both to the Genesee Valley area and to the east.

GEOLOGIC SETTING

The Devonian Appalachian Basin deposits of New York have long been known as a global reference section. The presence of a relatively complete stratigraphic succession, as well as an onshore-offshore gradient from red beds to black shales, is ideal for studies of stratigraphy, paleoecology, and sedimentology. These strata were deposited within a foreland basin resulting from the Acadian Orogeny; during which oblique convergence occurred between the Laurentia and Avalon terranes (Ettensohn 1985; Ver Straeten and Brett 1995, Ettensohn et al. 1988). Erosion of the collisional highlands produced the classic progradational complex known widely as the "Catskill Delta", which advanced in a generally westward direction and largely filled the foreland basin by the early Mississippian. More specifically, this trip focuses on a portion of the delta progradation (Ithaca Fm.) resulting from the creation of accommodation space following the third collisional tectophase of the Acadian orogeny which involved cratonward emplacement of overthrusts which depressed the lithosphere to enhance the foreland basin (see Ettensohn 1998).

This tectophase drastically changed both the geological and biological character of the basin. Following deposition of the Tully Limestone, orogenic activity caused major basin subsidence which was coincident with eustatic sea level rise (Johnson et al. 1985). This resulted initially in the deposition of the black Geneseo Shale, and its equivalents, over much of the Appalachian Basin. Furthermore, these basinal changes (and probably associated global warming) may have caused what is called the global Taghanic Bioevent, which resulted in the demise of Middle Devonian faunas worldwide (Aboussalam et al. 2001, Aboussalam 2003). Past observations suggest that this fauna returns anachronistically in the Appalachian Basin within the Ithaca Formation, and subsequently, in younger strata (Williams 1913). During the time of the deposition of the Geneseo Shale, the foreland basin was for the most part devoid of benthos, except for organisms adapted to a dysaerobic sea floor (*Pterochaenia, Buchiola*, rare chonetid brachiopods). This was episodically punctuated by times of slightly better bottom-water conditions, resulting in the deposition of the Fir Tree and the Lodi Limestones and their associated faunas (Baird et al. 1988). During and following this interval, progradation outpaced the rise of sea level, resulting in the deposition of the coarser-grained Sherburne and Ithaca Formations. Between the time of deposition of these formations, which are primarily comprised of turbiditic sequences, another sea-level deepening resulted in the deposition of the Renwick Shale. It is during the shallowing phase after the initial sea level rise associated with the Renwick Shale that the 'recurrent Hamilton Fauna' is first observed.

LOWER GENESEE GROUP STRATIGRAPHY

Background

Units seen on this trip were deposited as sediment along the delta-front during early Frasnian time. Correlation from the thin, basinal deposits of western New York into the delta-front area around Cayuga Lake has long been plagued by a variety of factors, including: misunderstanding of facies relationships (intertonguing), under-estimation of the thickening rate of these strata and within bed lithological variation, and also a case of biostratigraphic misidentification (see Kirchgasser 1985 and Williams 1951 for a complete summary). In addition, eastern sections are physically prohibitive; the 50-fold eastward thickening of the Genesee succession from Lake Erie to Ithaca and the sheer size of waterfalls and cliff walls in the eastern sections renders any attempts at regional section matching difficult, and access to the entire succession somewhat problematic.

Chadwick (1933, 1935) was the first to realize that the stratigraphic sequence of Genesee, Portage, and Chemung was also seen in the complex intertonguing of facies representing an offshore to onshore gradient (Genesee to Portage to Chemung facies). Around this same time, Caster (1933, 1933a) focusing on Ithaca area sections, attempted to divide the Ithaca Formation into traceable units as will be explained below. G.Q. Williams (1951) further expanded upon this work. Subsequently, the tracing of the Middlesex and Rhinestreet black shales into the area of Cayuga Lake by Sutton (1959, 1963), Sutton et al. (1962), and deWitt and Colton (1959, 1978) correctly placed both the Sherburne and Ithaca Formations within the Genesee Group (also see Rickard, 1964, 1975, 1981). Following this, examination and revision of Genesee Group ammonoids by House and Kirchgasser (see Kirchgasser and House 1981, Kirchgasser 1985, House and Kirchgasser 1993, Kirchgasser 2000, and references therein) began the process of building a high-resolution biostratigraphic correlational framework for the Genesee Group. Specifically, the location of the "Linden Horizon" yielding the ammonoid

Koenenites styliophilus in the Cayuga Lake section provides a datum from which other marker beds in the western section can be located in the Cayuga Valley (Kirchgasser, 1985). Also, Baird et al. (1988) correlated the Fir Tree and Lodi horizons from the west into the vicinity of Cayuga Lake and beyond, further aiding in high-resolution correlation of the Genesee Group across New York. Huddle (1981) attempted biostratigraphic correlation using conodonts, but his efforts were focused mostly in western New York and likely need some taxonomic revision in order to be applied to the more recent zonations provided by Klapper and Johnson (1990, also, see references therein). Most recent summaries of the information provided above can be found in Kirchgasser (2000), Baird et al. (2006), and other references therein.

Pre-Ithaca Formation Strata

Pre-Renwick Units.—Underlying the Renwick Formation in the study area are the Geneseo and Sherburne Formations. The Geneseo Formation as described above is an anoxic black shale, deposited as part of the Taghanic Onlap event representing a substantial eustatic sea level rise (Johnson 1970, Baird and Brett 2003). Brief excursions of more oxic conditions resulted in the deposition of the Auloporid-rich Lodi and Fir Tree Limestone submembers (Baird et al. 1988). Beginning around Seneca Lake, and continuing eastward, the upper portion of the Geneseo Formation (including the Fir Tree and Lodi Limestone submembers) begins to interfinger with the turbiditic siltstones facies of the Sherburne Formation (Vanuxem 1840), and in the vicinity of Ithaca, the shales of the Penn Yan Formation have completely lost their identity to such a facies transition. Recent mapping has identified a condensed horizon above the Fir Tree and Lodi Limestone submembers within the Sherburne Formation (Figs. 1 and 2), but further work is needed to determine if this bed is even traceable. If this bed can be traced, this would allow for differentiation of the Sherburne Formation into smaller units. In this trip we will give a brief overview of sub-Ithaca units, and then focus on the strata above the Sherburne Formation, beginning with the first known traceable unit above the Lodi Limestone submember, the *Warrenella* Zone of the basal Renwick Formation.

Renwick Formation.—The name Renwick was originally proposed by Caster (1933) in an abstract and later in a fieldtrip guidebook (1933a), but no specific type locality was listed. Included in Caster's (1933a) Renwick is the "Ithaca *Lingula* Shale" of Williams (1906), which is also the "*Lingula complanatum* Zone" of Williams et al. (1909). G.Q. Williams (1951) described this interval as having a stratigraphic range of about 30 meters, but gave only an arbitrary lithological upper boundary. As a lower boundary, Williams (1951) used the base of the *Warrenella* Zone of Williams (1884), Kindle (1896, 1906), and Williams et al. (1909), thereby including it in the Ithaca Formation. Previously this was equivalent to the Cornell Member of the Sherburne Formation as proposed by Smith (1935). The Renwick was later named for exposures along Renwick Brook, to the northeast of Ithaca (deWitt and Colton 1959, 1978). In doing so, deWitt and Colton (1959, 1978) also removed the Renwick from the Ithaca, giving it 'equal' stratigraphic status. As defined here, the Renwick Formation begins at an abrupt contact of dark shale with the underlying siltstones of the Sherburne Formation; near the base of the *Warrenella* (*Spirifer laevis*) Zone. While the faunal boundary is likely to be facies-related and therefore diachronous, further detailed mapping of the Sherburne-Renwick contact interval is necessary so that a suitable, isochronous boundary can be given for the base of the Renwick.

The top of the Renwick has been defined previously, first, as the contact with the Sixmile Creek member of Caster (1933); however this name is not used in Caster (1933a) or subsequently by other researchers, and, second lithologically, at the top of the youngest siltstone-filled channel in the sequence of dark shale and intercalated siltstone that composes the Renwick, by Williams (1951), deWitt and Colton (1978), and Grasso et al. (1986). We place the top of the Renwick Formation much higher, at the base of the Ithaca Falls limestone submember of the Ithaca Formation (Fig. 1, see below), and thereby abandoning any use of the name Sixmile Creek member. Within the Ithaca area, the Renwick Formation varies in thickness from 30 to 45 meters. Recent measurement of the section at Renwick Brook failed to locate the Ithaca Falls limestone with confidence; this gully has many covered intervals due to the numerous roads that cross it as well as a number of man-made retaining walls. Further work is necessary in order to find the Ithaca Falls limestone at this locality with certainty; or determine a new type section for the Renwick Formation as defined herein.

Further mapping of the Renwick Formation should allow division of this unit into different members. Some possible divisions include: the Cornell Shale of Smith (1935) (*Warrenella* Zone of Williams (1884), Kindle (1896, 1906), and Williams et al. (1909); the "Ithaca *Lingula* Shale" of Williams (1906) (also the "*Lingula complanatum* Zone" of Williams et al. (1909)); and a separate division for the upper, more siltstone-rich unit.

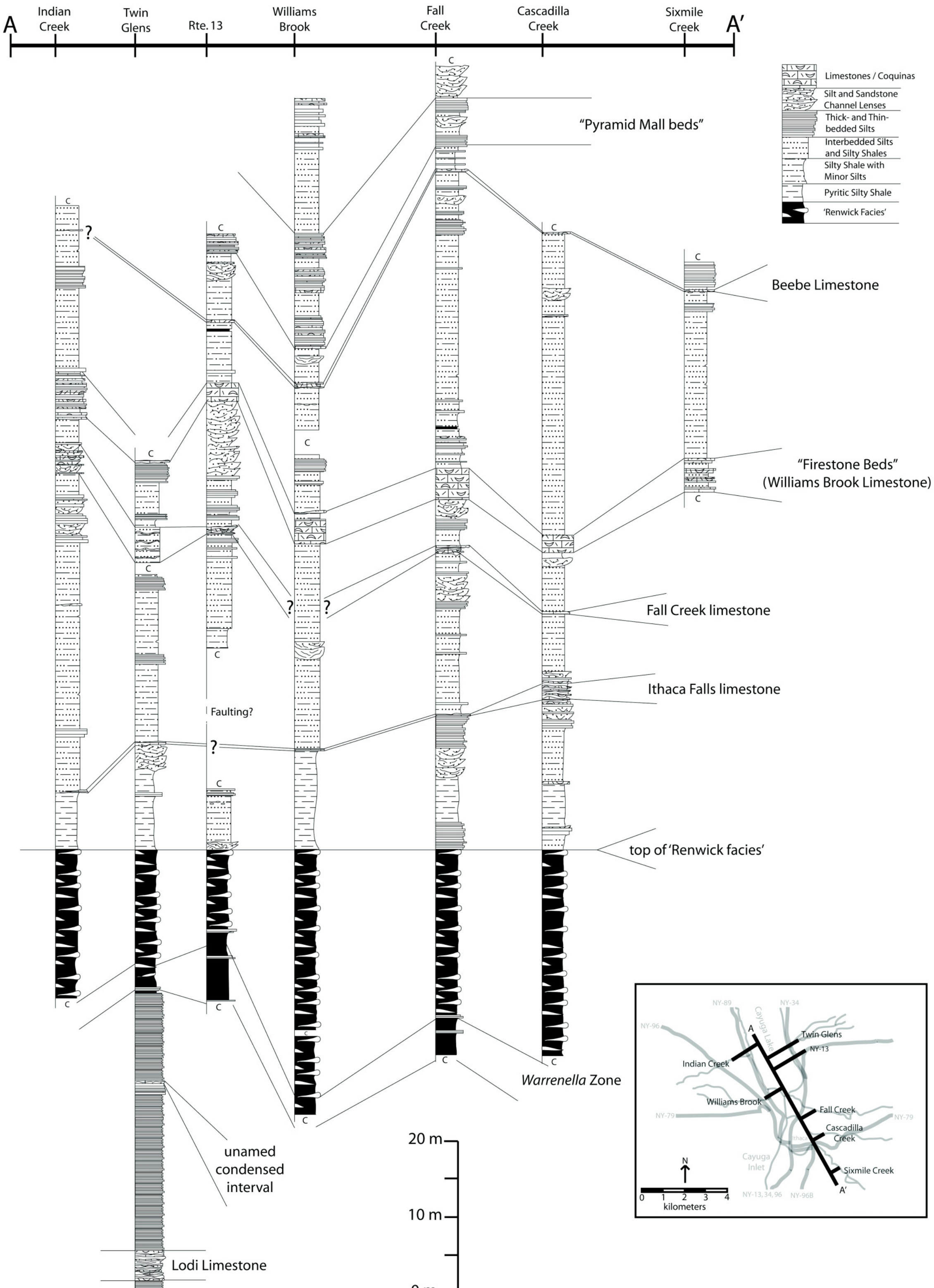
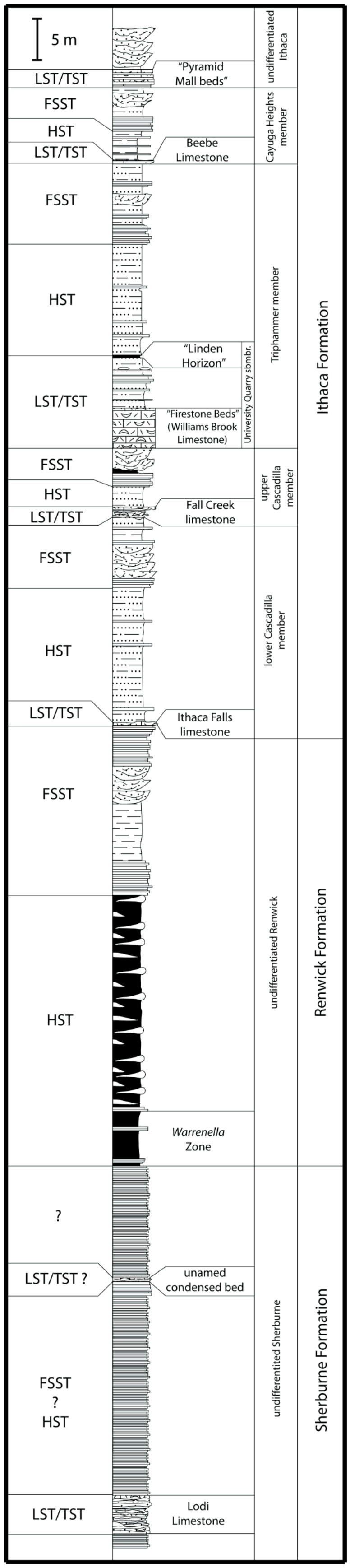


FIGURE 1—Stratigraphic correlation of various sections in the vicinity of Ithaca, New York; transect follows inset map. Stratigraphic nomenclature is discussed in text.



The term 'Renwick facies', is used herein to refer to the dark, thin-bedded shales and silty shales with interbedded siltstone channel lenses, which overlies the *Warrenella* Zone. This consists of the lowest portion of the Renwick Formation, comprised of the "*Lingula* Shales" of Williams (1906) and the numerous siltstone channel fills that locally cap many small cascades, and will be visible at STOPS 1B, 2, 3, and the optional stop. The 'Renwick facies' varies in thickness within the study area from 20 to 35 meters. This term is useful because it refers to the interval of the Renwick Formation (as defined here) that is equivalent to the Renwick of past researchers (Williams 1951, deWitt and Colton 1978, and Grasso et al. 1986). These channel fills commonly have basal lag deposits and exhibit soft-sediment deformation. These deformation features are typically seen at the base of siltstone channel complexes. In order for such channels to form, it is presumed that there was initial scouring into the sea floor, such that the base of the channel would be in a semi-compacted, or firm, mud. If this was the case, then load casts and ball and pillow structures by density inversion alone may not be sufficient to form these features. Some form of liquefaction of the firm, muddy base of the channels must have occurred; seismic activity would be one such possible trigger for liquefaction of thixotropic mud.

The Renwick Formation has a number of distinct faunal zones. The fauna of the *Warrenella* Zone includes: *Warrenella laevis* (with *Vermiformichnus* borings), *Cyrtina hamiltonensis, Arcuaminetes scitulus, Sinochonetes lepidus, Lunulicardium ornatum, Paleoneilo filosa, P. constricta, Pseudoaviculopecten* sp., *Modiomorpha sublata, Grammysioidea subarcuata, Nuculoidea* sp., *Glyptotomaria capillaria, Eutaxocrinus* sp., *Ponticeras perlatum,* Orthocones, plant and wood fragments. *Warrenella laevis* is an immigrant brachiopod from the Old World Realm fauna of western North America. See Williams (1884) and Kindle (1896) for a more complete species list. This interval will be accessible for collection at STOP 2 and the optional stop.

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FIGURE 2—Sequence stratigraphic interpretation of the strata as discussed in text. This is a composite section of strata measured at the Fall Creek, Twin Glens, and NY-13 localities.

The fauna of the ‘Renwick facies’ is rather similar to the shales below, with the addition of *Plumulina plumaria, Cupularostrum* sp.*, Phthonia* sp., *Cypricardella* sp., *Paleozygopleura* sp., various species of *Lingula* (hence the name “*Lingula* shales”), *Productella* sp., ‘Leiorhynchids’, and the absence of *W. laevis*. From the top of the ‘Renwick facies’ upward to the base of the Ithaca Falls limestone, the remainder of the Renwick Formation is a shallowing upward succession of rusty-weathering pyritic silty shales, thin- and thick-bedded siltstones, and silt and sandstone channel lenses displaying deformation and possibly altered volcanic ash beds (bentonites). This is the position of the ‘Recurrent Hamilton’ fauna as proposed originally by Williams (1884) and subsequently defined in greater detail (Williams 1913 and references therein). The fauna of the uppermost Renwick Formation is similar to the ‘*Lingula*’ shales below, with the addition of *Ambocoelia umbonata, Elyta fimbriata,* “*Mediospirifer*” *angusta, Tylothyris mesacostales,* and *Rhipidomella* sp. (Williams 1884). Although more work is necessary, this may be interpreted as a slightly more aerobic version of the fauna of the ‘*Lingula’* shales and both faunas may be considered ‘Hamilton-like’; the recurrence of the Middle Devonian ‘Hamilton fauna’ within the Frasnian deposits of the Finger Lakes Region is currently being investigated as part of the dissertation research of JZ.

Stratigraphy of the lower Ithaca Formation in the vicinity of Ithaca

Accounts in the past literature of the Ithaca Formation contain observations of a prograding delta into the basin, the introduction of the Ithaca fauna into the area of Cayuga Valley, and the observation of a variety of coquinitic lenses that were thought to be only local, and therefore could not be correlated between sections (Williams 1884, Kindle 1896, deWitt and Colton 1978, W.H. Hass in Huddle 1981). Recent mapping during the last two field seasons, however, has identified a number of condensed horizons that can be traced around the area of Ithaca. We present the current status of our correlations below and propose an informal stratigraphic nomenclature based on our correlations using a sequence stratigraphic approach (Figures 1 and 2). The benefit of using this approach to delineate boundaries between sedimentary sequences is that it places unit boundaries at the contacts of traceable, and presumably isochronous beds, rather than at an arbitrary lithological change. In particular, we have traced these condensed, fossiliferous units around the Ithaca area. Such beds are interpreted as being deposited during transgressions, when sediment supply to the basin is presumed to be sequestered onshore, allowing for the accumulation of time-rich, fossiliferous beds. Although most sediment was sequestered in such a way during these times, variation within the amount of condensation seen within traceable beds argues that sediment influx was still occurring and may have been locally sporadic (see below). It is believed by the current authors that this variability, probably in conjunction with shifting depocenters, is what led to problems with attempts of earlier workers to produce a high-resolution stratigraphic correlation. It was the recognition of this variability that allows us to produce such correlations within the Cayuga Valley. Our correlations are further supported by stratigraphic, faunal, and biostratigraphic evidence.

We intend for these names to be informal and serve as a guide for correlating mappable units into the sections of western New York, whereby possible correlations with western marker beds would allow for correct labeling of the tentative, ‘working-hypothesis’, marker beds presented here. The list of stratigraphic nomenclature within the Ithaca Formation has a long and varied history. Whenever possible we attempt to use the first name given to a unit, provided 1) the name represents a meaningful geographic location, and 2) the unit fits reasonably well into a sequence stratigraphic framework that allows high-resolution correlation of marker beds. We also use the informal subdivision of “submember” to denote intervals, up to several meters in thickness, of distinctive lithology. This is particularly advantageous in the current study, in that condensed units (which are the units that are traceable) are typically intervals of strata, rather than discrete “beds”. The following will proceed from the oldest to the youngest beds found in the lower Ithaca Formation.

Lower Cascadilla Member.—The name Cascadilla was originally used by Caster (1933, 1933a) presumably for the exposures along Cascadilla Creek, but no boundaries for this unit or a type section were given. G.Q. Williams (1951) subsequently defined this unit from the top of his Renwick to a level above the Williams Brook Limestone (see below).The lower Cascadilla member as defined herein commences with the Ithaca Falls limestone submember and is marked at the top by the base of the Fall Creek limestone submember. This interval is well exposed along the trail at Cascadilla Creek between Linn Street and College Avenue. This sequence is similar to the Renwick Formation, but lacks the ‘Renwick facies’. This is also the *Paracyclas lirata* Zone of Williams et al. (1909), another ‘Hamilton’ fossil. The Ithaca Falls limestone has been traced around Cayuga Lake and serves as the first distinctive marker bed above the *Warrenella* Zone (Figure 1). This bed is best developed in the cliff face above the lip of Ithaca Falls, for which it is named, and also in the southern-most gully of Twin Glens (STOP 4). This bed is typically a composite of fossil hash lenses, displaying a sharp erosional base, cross-bedding, interbedded turbiditic siltstones, reworked turbiditic siltstones; varying in thickness from a few to 34 cm. At Twin Glens these hash lenses are even seen to erode down through, and laterally truncate, a 10 cm thick turbidite. In more proximal (southeastern) localities, this bed is dominated by *Paleoneilo* sp., Nuculid clams, *Stictoptera meeki, T. mesacostales*, and abundant crinoid material. This bed commonly yields undeformed clams and gastropods with calcite replaced shells. At Twin Glens and Fall Creek there is a thin crinoidal hash layer found approximately at 40 and 20 cm, respectively, above this bed that has yielded articulated crinoids at Fall Creek. At more distal localities, in particular the section at Indian Glen, this bed yields an abundance of rhynchonellid brachiopods including forms exhibiting the characteristics of *Cupularostrum sappho, C. exima, C. contracta, Leiorhynchus quadricostatus,* cf. *Cherryvalleyrostrum limitare* (*"Leiorhynchus" limitare*), *C. mesacostalis,* and *Caryorhynchus globuliformes.* The overlying portions of the lower Cascadilla member include shallowing upward interbedded silty shales and thin siltstones, lithologically and faunally similar to the upper portion of the Renwick Formation. This interval ranges in thickness from 20 to 45 meters.

***Upper Cascadilla Member.*—**The interval herein termed upper Cascadilla member was included within the previously recognized Cascadilla member. The observation of a mappable fossiliferous interval within the Cascadilla member of older terminology, probably representing the transgressive interval of sea level change as discussed below, enables refinement and defines the lower/upper Cascadilla member boundary. Like the lower Cascadilla member, the upper Cascadilla member is well exposed along the trail at Cascadilla Creek downstream of the College Ave. Bridge. The base of this member is marked by the Fall Creek limestone submember, a newly recognized mappable unit within the Ithaca vicinity. This unit has been observed so far to be best developed on Fall Creek at the lip of the falls downstream from the old Cornell University Power Plant. These beds can be traced to slightly below the strata on which the Power Plant foundation is built. The top of this member is marked by the base of the "Firestone Beds" (see below). On this trip, these beds can be seen at STOP 5. The upper Cascadilla member ranges in thickness from 8 to 17 meters.

The Fall Creek limestone shows more variation in thickness than the Ithaca Falls limestone between localities. Faunally, these beds are extremely similar. These beds, when best developed as seen at Fall Creek, and at STOP 4, are a series of closely spaced coquinitic lenses. While not as sharp a contrast to the surrounding lithology as seen with the Ithaca Falls limestone, the Fall Creek limestone does stands out well relative to the relatively unfossiliferous strata found between the condensed marker beds presented here.

Faunally, the strata of the upper Cascadilla member are very similar to those below, with the addition of a small morph of ?*Orthospirifer.* The sequence of the upper Cascadilla member is typically similar to that of the lower Cascadilla member: silty shales with few interbedded siltstones coarsening upward to more abundant silts and finally, where present, packages of siltstone and sandstone channel lenses.

***Triphammer Member.*—**The term Triphammer member was first presented by Caster (1933, 1933a) presumably for exposures at Triphammer Falls on Fall Creek, yet no upper or lower bounds were specified. G.Q. Williams (1951) places this interval from a level above the Williams Brook Limestone (see below) to the base of the Enfield; an older stratigaphic name that included what is not only currently part of the Ithaca Formation but also the Middlesex Formation, and also other lower units within the Sonyea Group. This is the most studied and referred to unit in the Ithaca Formation, primarily due to this being the first incursion of the 'Ithaca fauna' into the area of study. Herein the Triphammer member is designated as beginning at the base of the University Quarry submember, an interval first described by Williams (1884). This interval was named such because it was formerly quarried by Cornell University for building stone (circa 1890); this abandoned quarry is thought to be somewhere along the edge of the Fall Creek Gorge (W.T. Kirchgasser, pers. comm., 2006). Williams et al. (1909) also identified the interval of the University Quarry at: Fall Creek (behind the Cornell University Power Plant), Cascadilla Creek (approximately half-way up the gorge), Williams Brook (between 600 and 650 feet elevation), as well as at the quarries along Quarry St., and the old McCormick Quarry. At Williams Brook, the Williams Brook Limestone of Caster (1933, 1933a; see also deWitt and Colton 1978) occurs at this elevation. The upper portion of the University Quarry interval, Caster (1933, 1933a) had called the Marathon Sandstone, presumably for an outcrop near Marathon, east of Ithaca. This is also likely the '*Spirifer mesastrialis* Zone' and the '*mesastrialis* sands' of Williams et al. (1909) and Williams (1913). The lower portion of the University Quarry interval was termed the "Firestone Beds" by Kirchgasser (1985), for an interval that is more fossiliferous, and therefore more calcareous, than the rest of the University Quarry interval. This term was used informally by Williams and Kindle to describe these beds and others like them, as the calcareous nature of these layers made them resistant to breakage during heating (Williams 1884, Kindle, 1896). Kirchgasser also identified the "Linden Horizon" near the top of the University Quarry interval. This is described as a sharp contact (flooding surface) on which the goniatite *Koenenites styliophilus* is abundantly concentrated. The University Quarry interval shows the first appearance of this goniatite in this succession and a key biostratigraphic marker bed, allowing correlation between the Cayuga and western sections including the type section of the horizon at Linden, NY, south of the City of Batavia in Genesee County. At its westernmost localities, the "Linden Horizon" is a condensed bed of styliolinid limestone abounding in the goniatite *Koenenites styliophilus*; it splays eastward across the Wyoming Valley-Honeoye Valley region into a thicker bundle of thin limestone beds yielding variable amounts of *Styliolina* and *Koenenites*.

Subsequently, Baird et al. (2006) mapped the Genesee Group in the area surrounding Linden, NY, and his observations suggest the possibility that Kirchgasser's " Linden Horizon" on Fall Creek may correspond to the erosive/corrosive flooding surface discontinuity that both caps and oversteps the condensed "Linden Interval" in the type Linden area (see also Kirchgasser and House 1981). Given that the "Linden Interval" thickens eastward, it appears likely that the University Quarry submember, including the "Firestone Beds" succession may be a greatly thickened eastern equivalent of the "Linden Interval" itself. Discovery of a goniatite specimen within the Caster Collections at the University of Cincinnati by one of the authors (JZ), which was subsequently identified as *Koenenites styliophilus* (Kirchgasser, pers. comm., 2007), further substantiates the possibility that *Koenenites* enters the succession during the time represented by the condensed interval ("Firestone Beds"), later to become concentrated on the sediment-starved flooding surface known as the "Linden Horizon". This specimen was labeled as "cascade at Power House Falls", which would place it below Kirchgasser's "Linden Horizon" on Fall Creek. This would indicate that the styliolinid grainstones commonly observed within the condensed "Linden Interval" in western sections may be correlative with the "Firestone Beds" in the Cayuga Lake section. We herein use the term "Linden Horizon" to represent the overlying, related flooding surface discontinuity (see below). The University Quarry submember is therefore a key marker interval that helps to put the strata above and below into the proper relationship to possibly correlative beds in western sections.

While the entire transgressive interval ("Firestone Beds" and "Linden Horizon") is included within the University Quarry interval, we find it useful to keep these names as mappable marker units. This is particularly important in westernmost New York where the post-"Linden Interval" corrosional discontinuity surface, roughly corresponding to Kirchgasser's "Linden Horizon" on Fall Creek, cuts out the "Linden Interval" (= "Firestone Beds"-equivalent succession) at all localities west of Murder Creek (Baird et al. 2006). Conversely, in eastern sections near Ithaca, the "Firestone Beds" appear to be more mappable than the "Linden Horizon" (Fig. 1). Furthermore, though the Williams Brook Limestone, which correlates to the "Firestone Beds" interval at other Ithaca area localities, is an impressive, 3+ meters-thick, deposit of shell-rich, pelmatozoan encrinite that shows internal channelization and cross-bedding, it is atypical compared to all other area sections. Hence, the name Williams Brook Limestone is herein used as a local name to represent this unique facies of the "Firestone Beds". Typically, the "Firestone Beds" are comprised of a complex of up to 4 meters of fossil-rich siltstones and coquina lenses.

In summary, we mark the base of the Triphammer member with the University Quarry submember (comprised of the "Firestone Beds" and "Linden Horizon"), as the name University Quarry apparently supersedes Marathon Sandstone, *S. mesastrialis* zone, '*Mesastrialis Sands*', "Linden Horizon", and "Firestone Beds". We mark the top of the Triphammer member with the base of the Beebe Limestone (Caster 1933, 1933a; deWitt and Colton 1978; see below). This bed was in the upper half of Caster's Triphammer member as originally defined. The thickness of the Triphammer member, as described herein, varies greatly from 10 to 40 meters.

The University Quarry interval marks the first appearance of the 'Ithaca Fauna' in this succession, characterized by such forms as *Orthospirifer mesastrialis*, *Cranaena eudora, Productella speciosa, Schizophoria impressa, Pseudoatrypa* cf. *devoniana,* "*Pugnoides*", Heterophrentid corals, *Platyceras* sp., *Koenenites* sp., and abundant disarticulated crinoid material. Some more 'Hamilton fauna' taxa also enter at these beds, including *Schuchertella* (cf. *Protoleptostrohpia*) and *Spinatrypa spinosa*. Fossils commonly show some pyritization in these beds. The strata from the University Quarry interval to the top of the Triphammer member, herein delineated by the base of the Beebe Limestone, are thickest in the section in the southeast of the study area, which agrees with deWitt and Colton (1978) and indicates that the source of sediment was from that direction (Fig. 1). At the section in Fall Creek, this interval is dominated by taxa of the 'Ithaca fauna' and shallows upward from silty shales and interbedded siltstones and silty shales, to heavier-bedded siltstones and eventually silt and sandstone channel deposits.

Cayuga Heights Member.—The Cayuga Heights member, so named for the exposures along the cloverleaf interchange of NY-13 and Cayuga Heights Rd. to the northeast of Ithaca, is a relatively thin sequence compared to those described previously. This interval will be observed at STOPS 5 and 7A. Although not as thick as lower members, the same succession from condensed, fossiliferous strata through silty shales, to thick-bedded siltstones and sandstones is still observed. The base of this unit is the Beebe Limestone of Caster (1933, 1933a), which has been correlated across the study area. The Beebe Limestone contains elements of the 'Ithaca fauna', similar to the "Firestone Beds". Like the "Firestone" Beds, the Beebe Limestone also displays dramatic thickness and lithological variations over small distances (discussed below). This bed was stated as occurring at about 40 to 45 meters below the Enfield in the Ithaca succession by Caster (1933, 1933a). Interestingly, based on Caster's description, the base of the Enfield is the equivalent of our "Pyramid Mall beds" (see below); 40 to 45 meters below this is about the level of the "Firestone Beds". The Beebe Limestone was not located by Williams (1951) in his study of the type Ithaca Formation, even after talking with Caster himself. deWitt and Colton (1978) describe the Beebe Limestone as occurring in the cliffs of Fall Creek west of Beebe Lake. Huddle (1981) describes the bed as occurring in the top of the Fall Creek Gorge near a bridge (possibly the Thurston Avenue bridge or the nearby foot bridge), as well as in float blocks at the bottom of the gorge. Both of these bridges are at least 35 meters above the "Firestone Beds". The present authors have located the float blocks, but have been unable to locate the Beebe Limestone in place west of Beebe Lake. There is no visible coquina near the footbridge, which is stratigraphically lower than the Beebe Limestone as we have defined it (see below). The base of the Thurston Avenue bridge is currently inaccessible due to ongoing construction, but its elevation is about where we would project the Beebe Limestone based on upstream information.

We have located what we understand to be the Beebe Limestone on the inlet gorge to Beebe Lake (northeast side) in place (STOP 6). While the float pieces within the gorge are a dense coquina with reworked phosphate pebbles and rip-up clasts, the Beebe Limestone on the far side of the Lake is a fossiliferous calcisiltite. We have observed both of these lithofacies, as well as intermediates, at similar stratigraphic levels throughout the study area. We discuss this variation, and that of the "Firestone Beds", below. Above the Beebe Limestone, *Warrenella laevis* has been reported by Kindle (1894) around Forest Home, on Fall Creek. Concurrent with the reappearance of *Warrenella* is a short return to deeper water deposits ('Renwick facies'), yet the 'Ithaca fauna' appears to persist above this. Above this, the section again shallows upward to siltstone and sandstone channel deposits (base Enfield of older literature). The Cayuga Heights member extends from the Beebe Limestone to the base of the "Pyramid Mall beds" (see below), attaining a thickness of approximately 5 meters.

Undifferentiated Upper Ithaca Formation.—The "Pyramid Mall beds", named for the exposure along NY-13 northbound next to the exit sign for Pyramid Mall and Triphammer Road, marks the base of the next heretofore undifferentiated member (STOP 5). This series of beds has also been located on Fall Creek upstream of the Caldwell Road Bridge in Forest Home, and at approximately 25 meters above the Williams Brook Limestone ("Firestone Beds") at Williams Brook. This bed consists of thin- to thick-bedded fossiliferous siltstones and sandstones, with a thickness of up to 8 meters (up to about 15 meters at Williams Brook). Crinoid material, *Schuchertella* sp., cf. *Protoleptostrohpia* sp., *Pseudoatrypa* cf. *devoniana,* and *Productella* sp. dominate the fauna of these beds. Based on observations at Fall Creek and Williams Brook (Fig. 1), what we herein call the "Pyramid Mall beds" may be more than one cycle. Further work and identification at additional sections should aid in sorting this out.

SEQUENCE STRATIGRAPHIC INTERPRETATION

Sedimentary Sequences at the Delta-front

Similarity observed in the sedimentary sequences presented above suggests some over-arching control on the amount of sediment being supplied to the basin; we interpret this as an affect of sea-level oscillation, assuming an approximate balance between basin subsidence and a relatively constant sediment supply. As sea-level initially rises, progradation of the delta slows and may stop completely depending on the rate and severity of transgression. During this time, sediment becomes sequestered in bays and estuaries, prohibiting the majority of the sediment supply, if not all, from reaching the basin. The initial onset of sea-level rise and the beginning of sediment sequestration is called the Lowstand Systems Tract (LST). The fastest rate of sea level rise, would result in condensed intervals, generally expressed as fossil rich limestones and calcareous silt and sandstones (Transgressive Systems Tracts, or TST). LST deposits are commonly reworked by overlying TST deposits such that these units may form a composite bed. Owing to the proximity of the study area to the sediment source, and the likely position along the delta-front, sediment supply may become reduced during transgressions but is not completely shut off, as one would expect in more basinal settings. In essence, in the overall Ithaca constructional (progradational) regime, even relatively "sediment-starved" TST intervals could effectively have been characterized by sediment bypass conditions at the delta front. This is evidenced by the 'splaying' open of coquinas with interbedded siltstones, as well as the variability observed within condensed intervals over a short distance as seen in the "Firestone Beds" and the Beebe Limestone. The "Linden Horizon" serves as an example of a flooding surface (FS), associated with the highest sea-level, and therefore the least amount of sediment input into the basin.

The character of the "Firestone Beds" at various localities is presented in Figure 3. At the Indian Creek and NY-13 localities, the "Firestone Beds" occur as highly fossiliferous interbedded silts and coquinas. At Williams Brook, this same interval is over 3 meters of channelized and cross-bedded thick-bedded limestone lenses (Williams Brook Limestone). At Fall Creek and Cascadilla Creek, this interval is again seen as coquinitic lenses with interbedded silt and sandstones. At Sixmile Creek this interval has a similar lithological character as Fall and Cascadilla Creeks, however the "Firestone Beds" here are dominated by *Heterophrentis* corals. One possible interpretation, for the thickening of sedimentary sequences towards the southeast following on the suggestion by deWitt and Colton (1978) that the source of sediment was coming from this direction, is that this transect represents the slope of the delta-front. The presence of abundant corals at Sixmile Creek and the observation of *Stromatopora* sp. in this interval near Fall Creek (Williams 1884) suggests that the shallowest portion of the transect presented is in the southeast. The Williams Brook Limestone can be interpreted as a submarine channel deposit along the delta-front slope. Relative to the "Firestone Beds" at other localities, the Williams Brook Limestone has thicker coquinitic lenses with a lower amount of siliciclastics within the calcareous portions. It would be expected that within a submarine channel there would be increased winnowing, as well as increased accumulation of fossils as channel lag deposits. A critical test of this interpretation would be to examine Williams Brook Limestone corals and brachiopods for abrasional degradation and biofacies incongruity relative to synjacent facies (= downslope transport). This is prima facie evidence for downslope displacement of large corals over a submarine escarpment in the Ludlowville Formation (see Bartholomew, et al., this volume). At Indian Creek and NY-13 the coquina lenses of the "Firestone Beds" are again splayed-open, possibly due to the increased sediment, winnowed from the area of the Williams Brook Limestone. Although not as clear-cut, the Ithaca Falls Bed may also show a similar gradient. The Ithaca Falls Bed is dominated by clams and bryozoans at the Fall Creek section, while 'Leiorhynchids' are only found in this bed at Indian Creek.

The Beebe Limestone submember also shows a good deal of variation between and within localities (Fig. 3). Following the same transect as the "Firestone Beds" above, the Beebe Limestone is a fossiliferous silty shale to calcisiltite at Indian Creek. This same bed is seen better developed at NY-13 were it is a calcareous pack- to grainstone. At Williams Brook this bed is again a fossiliferous silty shale to calcisiltite. At Fall Creek the Beebe Limestone shows the most variation, as a well developed coquina containing reworked phosphate pebbles and rip-up clasts in float blocks within the gorge, and as a pack- to grainstone upstream of Beebe Lake. At Cascadilla Creek this bed is again seen as a fossiliferous calcisiltite, and finally, at Sixmile Creek this bed is once again a well-developed coquina containing reworked pyrite-coated concretions. Similar concretions are observed approximately 2 meters below the Beebe Limestone at Williams Brook. Likewise, we attribute such variation to the presence of small submarine channels and variations in sediment supply.

Besides such variation in sediment supply during a systems tract, present correlations suggest shifting depocenters as well, as seen in Figure 1. The Renwick Formation is thickest at the southeast end of the transect, thinning toward the northwest. The lower Cascadilla member displays an opposite thickness trend along the transect. The upper Cascadilla member is relatively constant in thickness across the transect. The Triphammer member, like the Renwick, apparently thins from southeast to northwest. More work is necessary to understand the relationships of, and thickness between, the Beebe Limestone and the "Pyramid Mall beds" (Cayuga Heights member). Although likely shifting, the overall trend agrees with deWitt and Colton (1978) that the majority of the sediment supply was from the southeast.

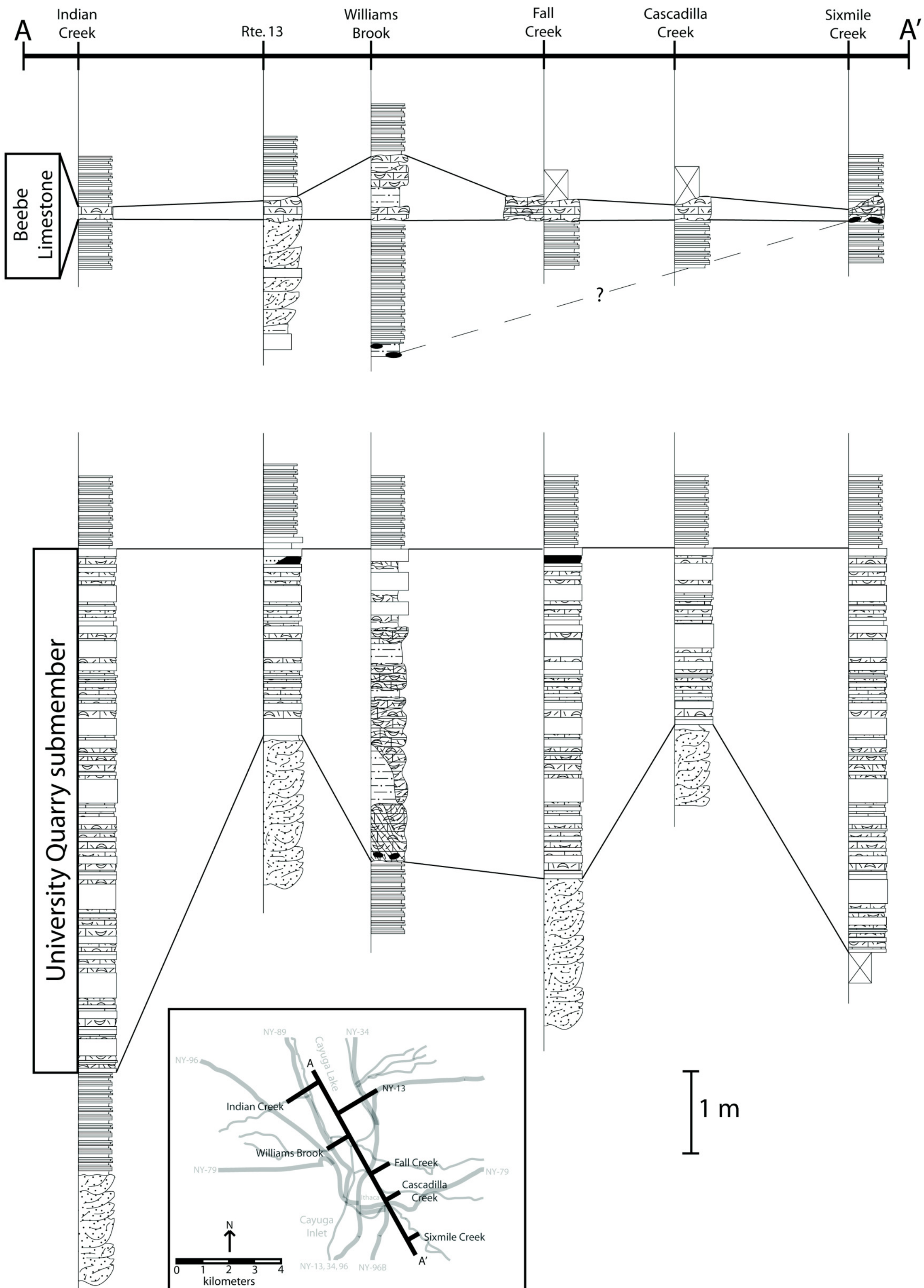

FIGURE 3—Lithological variation observed within the Beebe Limestone and University Quarry submembers at various localities in the vicinity of Ithaca, New York. Such variation is attributed to differences in sediment supply and shifting depocenters at the delta-front.

The rest of the sea-level oscillation is represented by strata that are relatively time poor and can be rather unfossiliferous (i.e. sediment diluted). This includes silty shales and interbedded thin siltstones representing deposition after progradation exceeds the rate of sea-level rise (Highstand Systems Tract, or HST). During sea-level fall, the sequence is seen as the thick-bedded silt and sandstone channel lenses observed (Falling Stage Systems Tract, or FSST). This is the shallowing (coarsening) upward pattern observed in each of the members described in this paper. The lowest point of sea-level, the sequence boundary (SB), would be observed at the base of the condensed interval of the next sea-level cycle and is used by us as the boundary between the described members of the Ithaca Formation. This boundary represents the lowest point of sea-level drop, and therefore when correlated between localities, is an isochronous surface. This surface is commonly composited (i.e. reworked) with the overlying TST, and can therefore be taken as the base of the condensed interval.

A summary diagram of the sequence stratigraphic interpretation of the lower Ithaca Formation is given in Figure 2.

CORRELATIONS WITH WESTERN SECTIONS

Now that we have a working hypothesis for sea-level cycle interpretation of the lower Ithaca and have identified a number of key marker beds within the Cayuga Lake area, it is possible to suggest tentative correlations with marker beds in western, more basinal sections. Because we interpret these condensed beds as forming during transgressions, it would follow that these should be traceable into discontinuity surfaces in the basin, as this is where a condensed interval should begin during a transgression. We outline such correlations in Figure 4.

Both the Fir Tree and Lodi Limestones have been well documented across western and central New York State (Baird et al. 1988). The Lodi Limestone is seen at the base of Twin Glens, just above the level of Cayuga Lake. Between the Lodi Limestone and the "Linden Horizon", which is herein understood to cap the University Quarry interval as discussed above, correlations are more uncertain. Kirchgasser (2000) suggests that the Renwick may be correlative to the Schumacher bed; a thin, conodont-rich black shale above the Lodi level, but this still has yet to be confirmed. Two fossil-bearing grey shale bands, informally termed the "Abbey Beds" (unpublished data) are observed to overlie the Schumacher Bed at the Rochester meridian; these may then correlate with the Ithaca Falls and Fall Creek limestones in the Ithaca sections presented here. Further fieldwork is needed to locate these beds in sections between Cayuga Lake and Genesee Valley.

The "Crosby Sandstone" (Fox 1932, Torrey et al. 1932) is a bed of resistant, sparsely fossiliferous, but bioturbated silt- to sandstone known from sections in the Keuka and Seneca valleys (deWitt and Colton, 1978). At the section at Mill Creek in Seneca Valley, this bed can be found above the "Linden Horizon" (University Quarry submember) correlatives (Kirchgasser and House 1981). It has not yet been confidently linked to Genesee Valley or Ithaca area localities (see discussion below), though it appears to be correlative with a bed of partially exhumed (truncated) concretions which is slightly below the Genundewa Formation in the Canandaigua Valley (Baird, 1976). In this region, Crosby Sandstone and correlative septarial concretions are overstepped westward across the Canandaigua Valley such that sub-Genundewa (upper Penn Yan Formation) dark grey shale rests unconformably on lower Penn Yan black shale deposits north of Seneca Point Glen. De Witt and Colton (1978) place the Crosby Sandstone at 70 to 80 feet above the Williams Brook Limestone at the section at Williams Brook. This corresponds well with the lower portion of a unit we have traced, and called the "Pyramid Mall beds". Huddle (1981) sampled the "Pyramid Mall beds" at Fall Creek for conodonts. The lack of *Ancyrodella rugosa*, unless due to facies restriction, suggests that this bed is older than the Upper Genundewa Limestone. Based on these observations, both the "Pyramid Malls beds" and the Beebe Limestone should be below the Genundewa Limestone in western sections. This is particularly troubling because the only known traceable, condensed unit between the "Linden Horizon" and the Genundewa Limestone is the Crosby Sandstone. The Crosby either represents both of these beds as a composite unit in western sections, or there is an, as yet, unrecognized discontinuity in the western sections as is suggested by the aforementioned dark shale-roofed discontinuity observed by Baird (1976) that oversteps the possible Crosby correlative in the Canandaigua Valley. The Starkey Black Bed of de Witt and Colton (1978), or more appropriately the base of this unit, is another possibly correlative bed, but more work is needed to understand the nature of this interval.

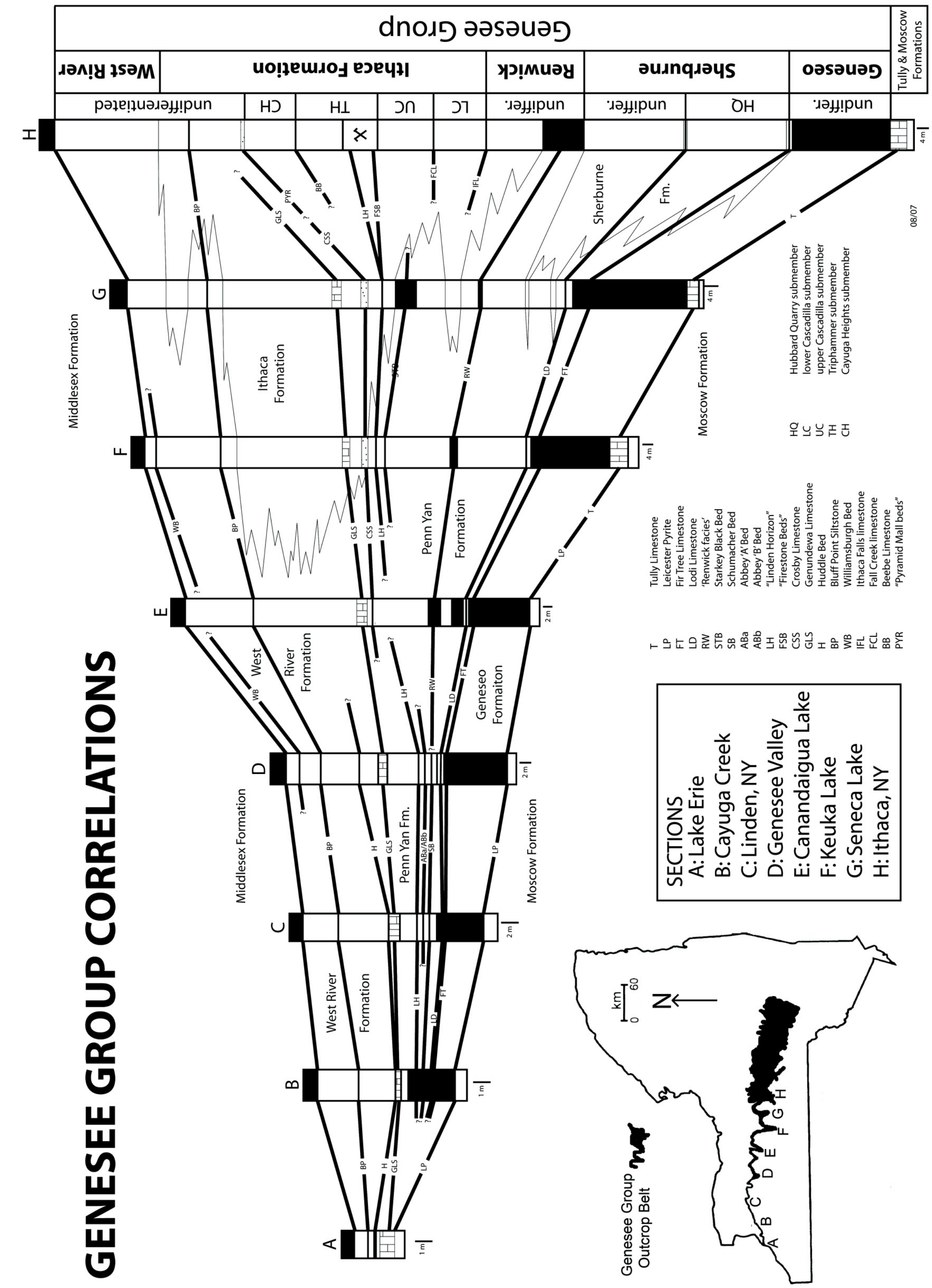

FIGURE 4—Correlations within the Genesee Group between Lake Erie and the Cayuga Lake Valley. This is modified from Kirchgasser (1985) with the data presented in this paper (see text for appropriate references).

The Genundewa Limestone and associated North Evans lag bed is a unique and dominant feature of the Genesee Group succession in westernmost New York (see summary of issues in Baird et al. 2006). Space does not allow extensive description of this ultra-condensed interval of styliolinid carbonate and associated discontinuities, but it must be noted that it is enormously time-rich and in western sections may potentially be equivalent to a thick portion of the upper Ithaca succession. The North Evans bone/conodont bed encompasses up to seven conodonts zones mixed as a composite lag where this unit oversteps the entire lower Genesee Group succession near Buffalo. Both the North Evans disconformity closes eastward to continuity within the Genundewa succession and the Genundewa itself thickens into a splay of discrete styliolinid limestone beds in the same direction (Baird et al. 2006). In existing literature, the Genundewa is unknown east of a locality (Schuman Cemetery) near Gorham, NY (deWitt and Colton, 1978). However, ongoing unpublished fieldwork by the present authors shows at least some portion of the Genundewa (both with Styliolinid limestone and “North Evans” aspect) is traceable through the Keuka Valley to the west side of the Seneca Lake Valley. These discoveries show the potential of linking this important, time-rich, unit into the Ithaca area. However, just how such a bed will look at the delta-front is uncertain; proximity to the delta-front has had a substantial effect on the development and variability of the condensed intervals presented above. It may be that the Genundewa correlative is present in the upper-most “Pyramid Mall beds”, especially if these represent more than one cycle. Finally, the current easternmost known limits of post-Genundewa divisions (conodont-glauconite-rich “Huddle Bed” of the basal West River Formation, goniatite-bearing Bluff Point siltstone bed of the medial West River Formation (see Kirchgasser, 1985), and pyrite clast/conodont-rich lag horizon of the Williamsburgh Bed of the topmost West River Formation) are also being extended toward the Ithaca area as part of ongoing fieldwork.

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ROAD LOG FOR TRIP B-4

RE-EXAMINATION OF THE TYPE ITHACA FORMATION: CORRELATIONS WITH SECTIONS IN WESTERN NEW YORK

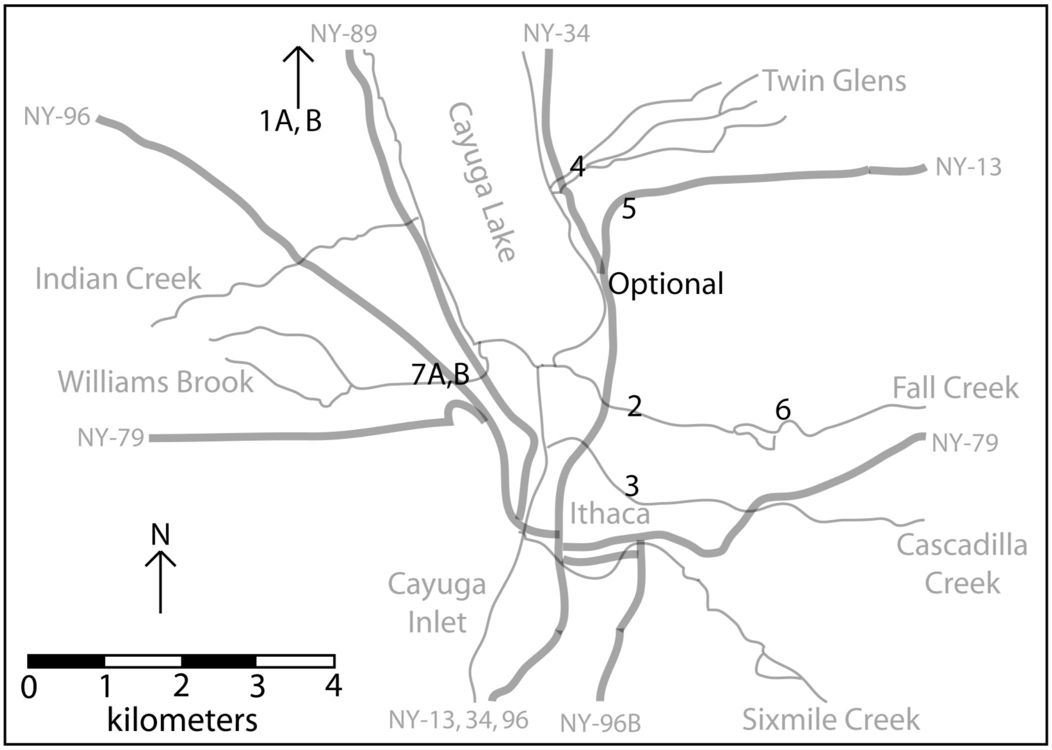

FIGURE 5—Location of stops to be made on this trip.

CUMULATIVE MILEAGE	MILES FROM LAST POINT	ROUTE DESCRIPTION
0.0	0.0	Begin roadlog at the entrance to SUNY Cortland, intersection of Tompkins St. (NY-13) and Pashley Dr. Turn right on Tompkins St. (NY-13 southbound).
1.3	1.3	Turn left following NY-13 southbound
1.8	0.5	Enter South Cortland
3.4	1.6	Cross Gracie/Webb Road.
4.5	1.1	Tompkins-Cortland County Line.
		0.25 mile long overgrown, but fossiliferous outcrop. The presence of *O. mesastrialis* and 'Pugnoides' places this within the Triphammer member, possibly the University Quarry submember (see Harrington 1970).
7.5	3.0	Pass entrance to Tompkins-Cortland Community College.

8.0	0.5	Enter the Village of Dryden.
8.4	0.4	Turn right, remaining on NY-13 southbound.
11.2	2.8	Pass Ringwood Road.
15.2	4.0	Cross Hanshaw Road.
16.3	1.1	Enter the Town of Lansing
17.1	0.8	Outcrop of West River equivalent strata at the intersection of Warren Rd.
17.7	0.6	Exit for Triphammer Road. Strata of the Ithaca Formation.
18.4	0.7	Exit for Cayuga Heights Road. Strata of the Ithaca Formation, this will be STOP 5.
19.7	1.3	Pass exit for NY-34.
20.5	0.8	Cross Dey/Willow Streets.
21.3	0.8	Turn Right on Buffalo St. (NY-89 northbound).
21.4	0.1	Turn right on NY-89 northbound (Taughannock Blvd.).
21.55	0.15	Bridge over Cayuga Lake Inlet.
21.6	0.05	Outcrops of Renwick Formation.
22.0	0.4	Cross Williams Brook (STOPS 7A and7B will be upper portion of this creek).
22.7	0.7	Enter Town of Ulysses.
25.4	2.7	Pass Cayuga Nature Center.
28.0	2.6	Enter Taughannock Falls State Park.
28.2	0.2	Park vehicles. Proceed along Taughannock Creek to waterfalls over the Tully Limestone

STOP 1A. TAUGHANNOCK STATE PARK (TULLY LIMESTONE)

Both STOPS 1A and B are used as an overview to put the Ithaca Formation in perspective with the underlying Middle Devonian strata. At the first stop, the Tully Limestone is accessible above the Moscow Formation of the Hamilton Group. As summarized in Baird and Brett (2003), the Tully represents both significant sedimentological and faunal changes in the Appalachian Basin. Sedimentologically, upper Tully divisions, commencing with the coral-rich Bellona Bed comprise a TST-succession that represents the onset of the Taghanic onlap, a eustatic sea-level rise that locally within the Appalachian Basin resulted in the deposition of the black Geneseo Shale Formation and its correlatives (Harrell, Burkett, etc, see Baird and Brett 2003). Faunally, this onlap is significant because it is concurrent with late stages of the global Taghanic Bioevent, resulting in the suspected demise of Middle Devonian faunas worldwide. As will be demonstrated later in this trip, the demise of the Middle Devonian 'Hamilton-fauna' in the Appalachian Basin may not have taken place at this boundary; 'Hamilton'-characteristic fossils can be found throughout the Frasnian of New York (see Williams 1913 and references therein).

Return to vehicles and continue along NY-89 northbound.

28.5	0.3	Turn right on Taughannock Park Rd.
29.1	0.6	Turn left into the falls overlook parking lot.

STOP 1B. TAUGHANNOCK FALLS OVERVIEW (LOWER GENESEE GROUP)

The overlook at Taughannock Falls provides a stunning view of the lower Genesee Group; including the Geneseo Formation, Sherburne Formation, and the lowest Ithaca Formation (Figure 6). Within the walls of this hanging valley both the Fir Tree and Lodi Limestone Beds can be observed. These beds, or associated discontinuities, can be traced throughout most of New York (Baird et al. 1988). Also visible within the gorge wall are the siltstone lenses characteristic of the 'Renwick facies', which will be observed in detail at later stops. This is purportedly the highest waterfall east of the Mississippi River.

Return to vehicles and continue west along Taughannock Park Road

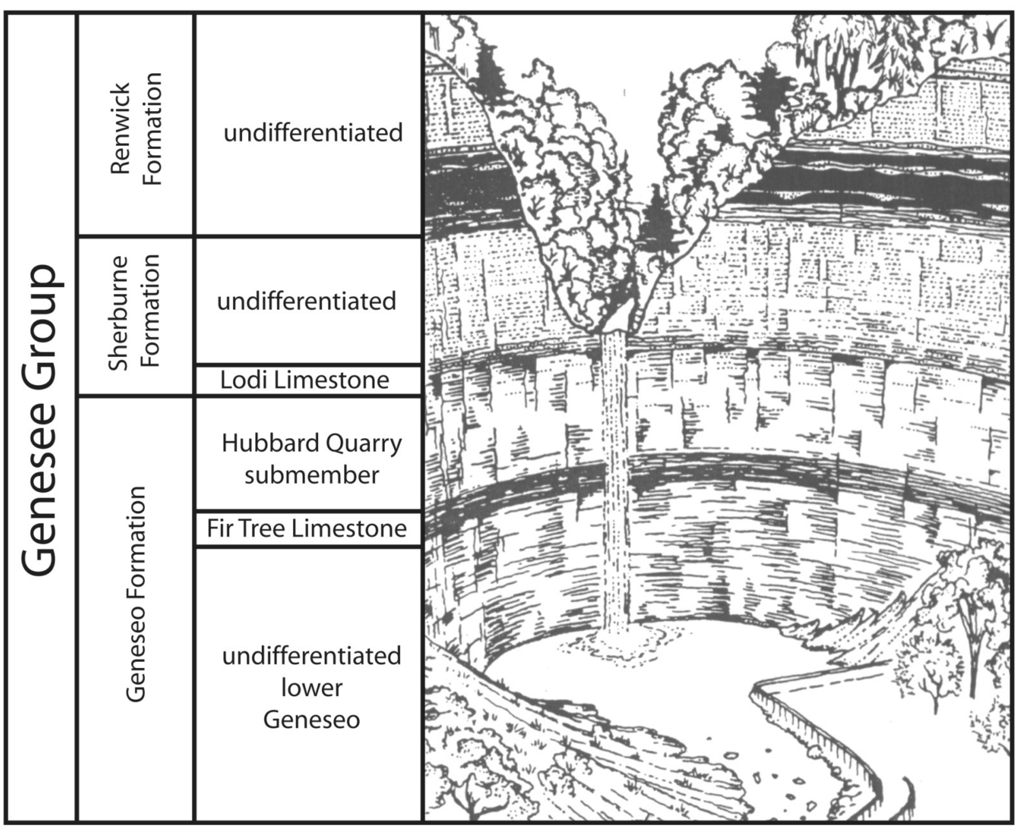

FIGURE 6— Diagrammatic representation of the view seen at the Taughannock Falls overlook. Modified from Baird and Brett (1986).

29.7	0.6	Turn left on Falls/Jacksonville Rd.
29.8	0.1	Cross Taughannock Creek.
30.3	0.5	Turn left on NY-96 southbound.
33.6	3.3	Pass Ithaca Antique Mall.
35.4	1.8	Pass Dubois Rd.
36.0	0.6	Pass entrance to The Paleontological Research Institution.
36.6	0.6	Enter the Town of Ithaca.
36.7	0.1	Cross Williams Brook and parking (STOPS 7A and 7B).
36.9	0.2	Enter the City of Ithaca. Williams Glen Road on left.
37.6	0.7	Pass outcrops of Renwick Formation.
38.1	0.5	Bridge over Cayuga Lake Inlet.
38.2	0.1	Turn left on NY-13/34 (northbound).
38.9	0.7	Bridge over Cascadilla Creek.
39.0	0.1	Right on Dey Street.
39.02	0.02	Left on Lincoln Street.
39.4	0.38	Proceed straight at the end of Lincoln Street, crossing Lake Street.
39.5	0.1	Park vehicles at Ithaca Falls Park.

STOP 2. ITHACA FALLS PARK, FALL CREEK (WARRENELLA ZONE SUBMEMBER)

This stop allows access to the Renwick Formation (Figs. 1 and 2). This section begins in the *Warrenella* Zone, near the base of the Renwick Formation. Above this and in the face of Ithaca Falls are the siltstone channel lenses characteristic of the 'Renwick facies'. Excellent collecting of the *Warrenella* Zone fauna is possible at this locality. The upper Renwick Formation is inaccessible at this locality, but can be accessed at the nearby gully running up through the old Ithaca Gun Factory, also known as Gun Hill. Due to reportedly high lead levels from test firing of rifles, this small gully and the Ithaca Gun Factory itself are currently posted.

Return to vehicles. Proceed left on Lake St.

39.6	0.1	Pass entrance of the Ithaca Gun Factory.
39.8	0.2	Right on University Avenue.
40.2	0.4	Right on Linn St. Park on the immediate left in the parking lot for the First Church of Christ Scientist.

STOP 3. CASCADILLA CREEK ('RENWICK FACIES')

This stop begins stratigraphically above the *Warrenella* Zone, within the siltstone lenses of the 'Renwick facies' (Figures 1 and 2). This is the "*Lingula* Shales" interval of H.S. Williams (1906). This outcrop offers collecting of the *Lingula* fauna, including *Plumalina plumaria* and articulated crinoids (*Eutaxocrinus ithacensis*).

Return to vehicles. Proceed with a right on Linn St.

40.3	0.1	Turn left on University Avenue.
40.7	0.4	Turn Left on Lake Street.
41.0	0.3	Bridge over Fall Creek (Ithaca Falls Park).
41.8	0.8	Turn right on NY-13 northbound, and park along the entrance ramp.

OPTIONAL STOP. NY-13 (RENWICK FORMATION)

This optional stop shows a continuous section of the intervals seen at STOPS 2 and 3. The base of the section is in the *Warrenella* Zone (Figures 1 and 2). Above this, the siltstone channel interval ('Renwick facies') is accessible for collection of the *Lingula* fauna as well as *Plumalaria plumalina*. Although this outcrop does not reach the Ithaca Falls limestone, the upper portion of this cut is interesting in that it affords the opportunity for close examination of large ball and pillow structures. This is approximately the arbitrary lithological boundary given to the Renwick and overlying Ithaca in the past literature.

Return to vehicles and continue along NY-13 northbound.

42.7	0.9	Enter Town of Lansing.
42.8	0.1	Exit at Cayuga Heights. The well-exposed outcrop along the cloverleaf of strata above the Renwick Formation will be examined later as part of STOP 5.
42.9	0.1	Turn right on Cayuga Heights Rd.
43.0	0.1	Turn right, returning onto NY-13, thistime southbound.
44.1	1.1	Exit at NY-34/Stewart Park.
44.3	0.2	Turn right following signs for NY-34 northbound.
44.5	0.2	Turn left on NY-34 northbound.
45.4	0.9	Park on side of NY-34 near (but 10 feet from) orange hydrant. Proceed on foot to trail along Twin Glens. This is private property, and permission must be granted for access.

STOP 4. TWIN GLENS (ITHACA FALLS LIMESTONE SUBMEMBER)

The focus of this stop is the Ithaca Falls limestone submember as well as the recurrent 'Hamilton fauna' in the surrounding shales (Figures 1 and 2). At this locality the Ithaca Falls limestone is well developed, showing a sharp erosional base, erosionally lateral-truncation of turbidites, and an angularly truncated upper surface. This bed is excellent for collecting calcite replaced *Paleoneilo* sp. and Nuculiid bivalves. Above this limestone is a thin bed of crinoid debris that has yielded articulated cladid crinoids (at Fall Creek). Surrounding this bed is a dysaerobic fauna with some characteristic fossils of the 'Hamilton fauna'. This includes *Paleoneilo* sp., Nuculiid bivalves, *?Mucrospirifer mucronatas (?'Spirifer' posterus, ?Tylothyris mesacostales), Glyptotomaria capillaria*, and abundant pelmatozoan material.

Return to vehicles and continue along NY-34 northbound.

45.5	0.1	Enter town of Lansing… once again.
46.5	1.0	Hard right onto Cayuga Heights Road.
47.7	1.2	Cross upper end of Twin Glens.
47.9	0.2	Turn left onto entrance ramp for NY-34 northbound. Park along side of entrance ramp.

STOP 5. NY-13 (UPPER CASCADILLA THROUGH CAYUGA HEIGHTS MEMBERS)

Excellent exposures are seen at the cloverleaf cut for the NY-13 interchange at Cayuga Heights Road. The lowest part of this exposure begins above the Ithaca Falls limestone. This section is continuously exposed upward to the "Pyramid Mall bed", therefore including the complete cycles represented by the upper Cascadilla, Triphammer, and Cayuga Heights members (Figures 1 and 2). At this section, the lithology of the University Quarry submember more closely resembles the "Firestone Beds" at Fall Creek, than to the Williams Brook Limestone (STOP 7A), and the Beebe Limestone is a calcisiltite rather than a well developed coquina as seen in the Fall Creek Gorge and at Sixmile Creek (see Figure 3). Most impressive at this section is the cross-sections of FSST siltstone channel complexes visible in the wall face. There is noticeably a large amount of covered section, on NY-13 between the optional stop and STOP 5, in fact larger than should be, given the correlations presented in this trip. Faunally, however, our correlations of the NY-13 section with the other sections studied do agree, and we presently interpret this large covered interval as possibly representing some unseen thrust-faulting resulting in stratigraphic duplication.

48.0	0.1	Return to vehicles and make a cautious u-turn along the entrance/exit ramp. Turn left onto Cayuga Heights Road, entering the Village of Cayuga Heights.
49.5	1.5	Ithaca City limit.
49.55	0.05	Turn left on Thurston Avenue.
49.8	0.25	To the right at the end of Highland Ave. is a suspension bridge and access into Fall Creek Gorge at the Cornell University Power Plant waterfalls and the 'type' "Firestone Beds". Proceed on Thurston.
50.1	0.3	Turn left onto Cradit Farm Road before the Thurston Avenue bridge.
50.4	0.3	Park in lot opposite observatory. Proceed along foot path to Beebe Lake.

STOP 6. BEEBE LAKE (BEEBE LIMESTONE SUBMEMBER)

This stop will show the Beebe Limestone in place near Beebe Lake (Figures 1 and 2). The lithology developed here is very dissimilar to the coquinitic limestone blocks seen downstream as isolated float below the Beebe Lake dam (see text and Fig. 3), but this section at least serves as an accessible type locality for this bed, which has been wanting ever since Caster (1933, 1933a) first named it. This stop also highlights local faulting within the Ithaca Formation. A down-dropped (?) fault block is seen just upstream of the Beebe Limestone.

Return to vehicles and turn right onto Cradit Farm Road toward Thurston Avenue.

50.7	0.3	Turn right onto Thurston Avenue.
51.2	0.5	Turn right onto Stewart Avenue.
52.8	1.6	Turn right onto NY-13 southbound.
54.1	1.3	Pass exit for NY-34.
55.8	1.7	Turn right onto NY-96 northbound; stay in left lane.
56.2	0.4	Pass outcrops of the Renwick Formation.
56.9	0.7	Pass Williams Glen Road.
57.1	0.2	Park on left side of road in pull-off at NY-96 and Hopkins Place. Proceed to end of pull-off and access Williams Brook upstream of NY-96.

STOP 7A. WILLIAMS BROOK (BEEBE LIMESTONE SUBMEMBER)

At Williams Brook, the Beebe Limestone is similar to that observed at STOP 6, a fossiliferous calcisiltite, but here more splayed open. The identification of this bed at this level agrees with Williams et al. (1909) in that the University Quarry interval is equivalent to the Williams Brook Limestone; and furthermore shows that both are distinctly older than the Beebe (Figures 1 and 2). Below the Beebe interval at this section, pyrite-coated concretions, similar to those reworked into the Beebe Limestone at Sixmile Creek, can be observed. If time permits, the "Pyramid Mall beds" are accessible just upstream of here.

Proceed across street and onto Private Property to access the Williams Brook Limestone; permission must be given by landowner.

STOP 7B. WILLIAMS BROOK (WILLIAMS BROOK LIMESTONE)

The Williams Brook Limestone (Caster 1933, 1933a) is one of the most impressive deposits to be seen on this trip. The interval of the coquina itself is approximately 3 meters thick, capping a small waterfall. Channelized bedforms, cross-bedding, truncated inter-bedded siltstones, and reworked concretions and rip-up clasts can be seen within the coquina. The local representation of the "Firestone Beds" at this locality, as well as the channelized bedforms observed in cross-section, suggest deposition within a submarine channel (Figures 1, 2, and 3). The beds above the coquina (Marathon Sandstone of Caster (1933, 1933a), '*Spirifer mesastrialis* Zone', and the '*mesastrialis* sands' of Williams et al. (1909) and Williams (1913)) contain abundant fossils at some horizons, including *Gomphoceras tumidum*.

Return to SUNY Cortland via NY-96 southbound to NY-13 northbound.

END OF FIELD TRIP