AN EARLY LATE DEVONIAN BONE BED-PELAGIC LIMESTONE SUCCESSION: THE NORTH EVANS-GENUNDEWA LIMESTONE STORY

In memory of Daniel B. Sass (1919-2006)

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INTRODUCTION

The Genesee Group succession in western New York represents deposition in dysoxic to near-anoxic settings in the subsiding Appalachian foreland basin (Fig. 1) that records a series of widespread sedimentary and biological events. We will focus on lower and medial Genesee divisions that record changes in the basin that range in age from latest Middle Devonian into the early Late Devonian. In particular, we are interested in the genesis of styliolinid (pelagic) limestone units and associated bone-conodont beds. This paper will examine the results of recent mapping and biostratigraphic work on a succession of units in the Genesee Group, ranging, in upward succession, from basal Geneseo black shale facies into the lower part of the West River Formation. We will also highlight the discovery of two mappable discontinuity-related bone-conodont beds in the lower part of the Genesee succession. The most important part of this project is the study of the regional character and inferred genesis of the North Evans Limestone (a famous conodont-bone lag unit above a major discontinuity) as well as that of the Genundewa Formation, a distinctive layer of pelagic, styliolinid carbonate that overlies the North Evans. We will examine closely the relationship of the Genundewa to both the North Evans lag deposit and overlying basal beds of the shaley West River in the context of inferred flexural and eustatic events within the basin. Another focus of this project is to better elucidate the complex chronostratigraphic story recorded in this stratigraphically condensed succession.

The change from Middle Devonian (Late Givetian), neritic shale facies of the Windom Member (Moscow Formation) of the Hamilton Group into black, condensed, basinal deposits of the lower Genesee Group [latest Givetian and earliest Late Devonian (basal Frasnian)] is abrupt and profound (Fig. 2). This change, across the widespread top-Windom, Taghanic disconformity in western New York was what initially lured two of us (Baird and Brett) away from fossil-rich Hamilton deposits into a mysterious parallel universe of black mud deposition and hypoxic water mass chemistry. The study of the genesis of exotic facies such as the diachronous, detrital pyrite deposits of the Leicester Pyrite along the disconformable base of the Geneseo black shale marking the base of the Genesee Group (see Fig. 2) was critical in understanding the genesis of black shale-roofed unconformities (Baird and Brett, 1986, 1991; Baird et al., 1989). Although work relating to the genesis of such contacts was directed to basinal units elsewhere in succeeding years, detailed study of the Genesee Group above the Taghanic unconformable contact has continued. Detailed biochronostratigraphic studies of Genesee divisional units are also ongoing. Application of new advances in sequence stratigraphy and recognition of the importance of basin flexural tectonics in the evolution of the Devonian foreland basin

(Ettensohn, 1987, 1994, 1998), make the condensed western New York Genesee Group succession ideal for the testing of models (see Figs. 1, 2).

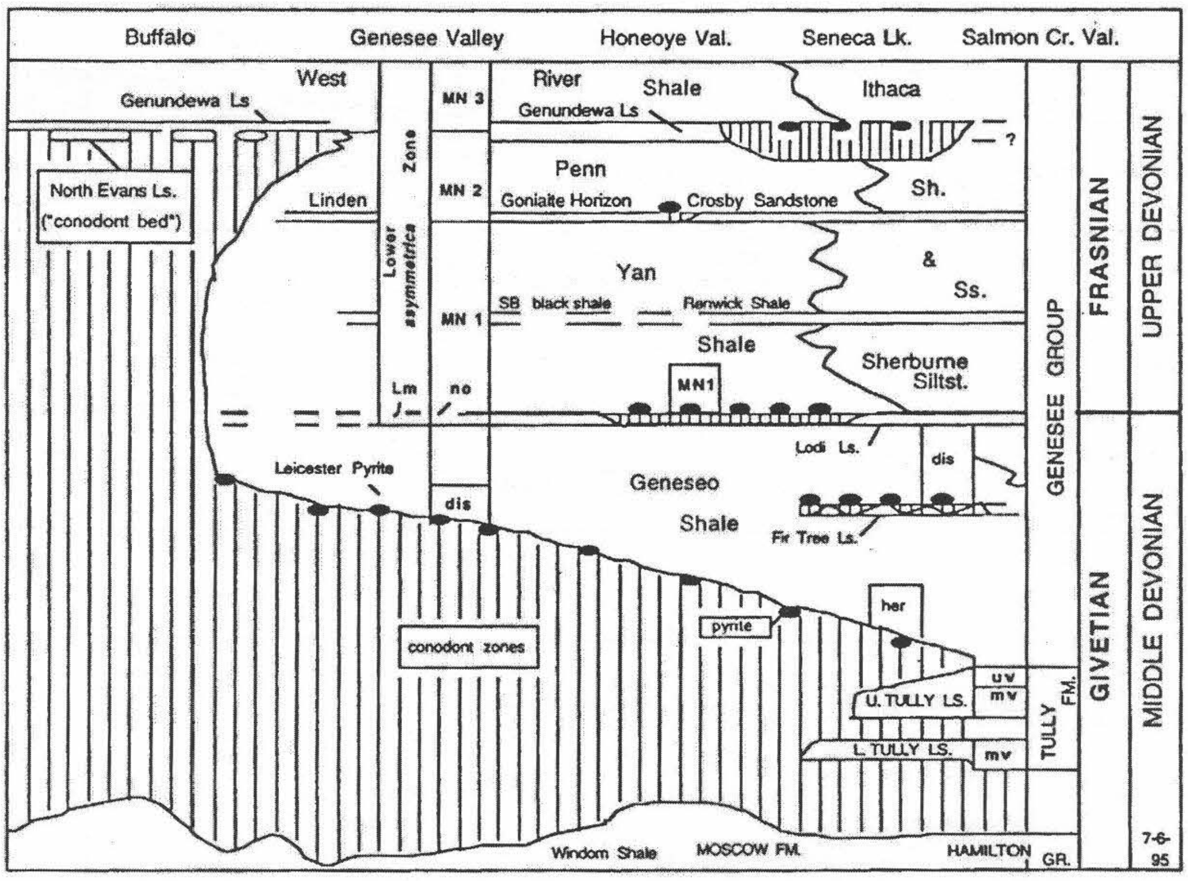
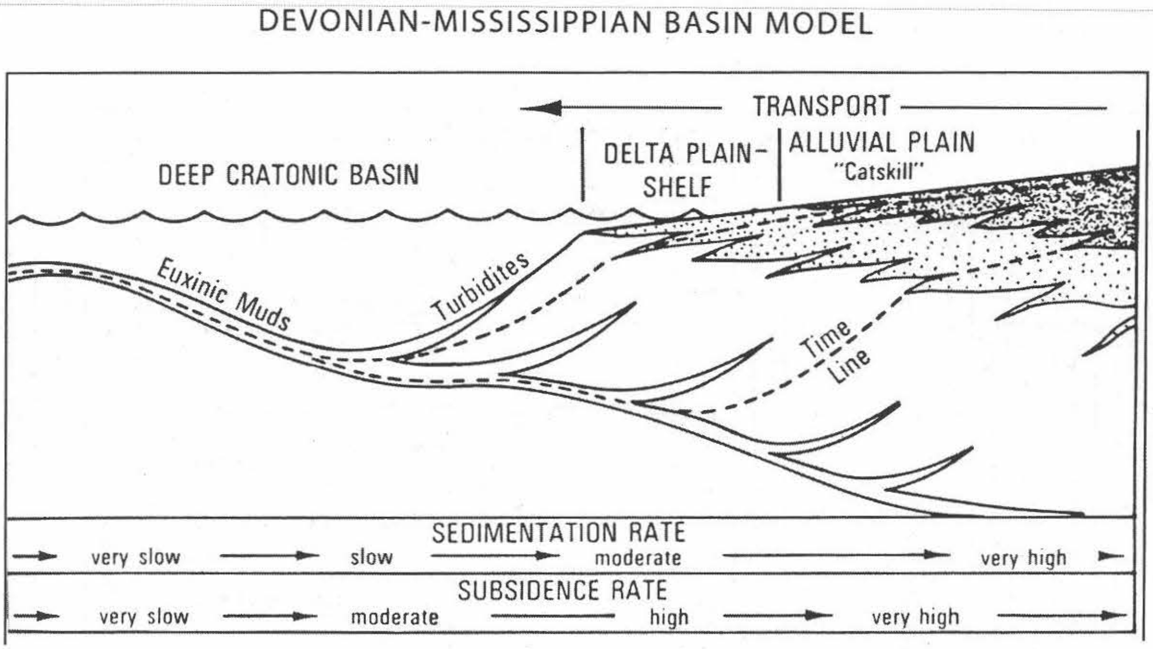


Figure 1. Generalized chronostratigraphic cross-section of lower Genesee Group and subjacent Moscow Formation (Hamilton Group, Windom Shale Member). Large hiatus below Genesee Group marks position of compound Taghanic Unconformity, Genesee onlap succession, and sub-Genundewa unconformity. The pre-Tully erosion- Hamilton erosion surface marks a major sequence and tectophase (III) boundary. The lenses of detrital Leicester Pyrite are derived from this erosion but were deposited through a long period of diachronous onlap of Genesee black muds from this discontinuity during the Taghanic transgression. The locally beveled beds with pyrite and fish debris include condensed styliolinid limestones and nodules (Fir Tree, Lodi, Abbey, Linden, Crosby, Genundewa) associated with surfaces of maximum sediment-starvation formed during pulses of sea level rise. In this report these horizons have been traced to the most highly condensed westernmost sections. The North Evans Limestone (conodont bed) in the Buffalo area in western Erie County is a lag deposit of crinoid, fish, and conodont debris that accumulated in shallow water over the peripheral bulge at the west margin of the basin where the gap of the compound unconformity is greatest. Lenses of North Evans debris [with Middle *varcus* to MN Zone 2 conodonts and Frasnian goniatites (*Koennites*)] are traceable beneath the sub-upper Genundewa disconformity as far east as the Genesee Valley. From Kirchgasser, Brett and Baird, 1997, fig. 7).



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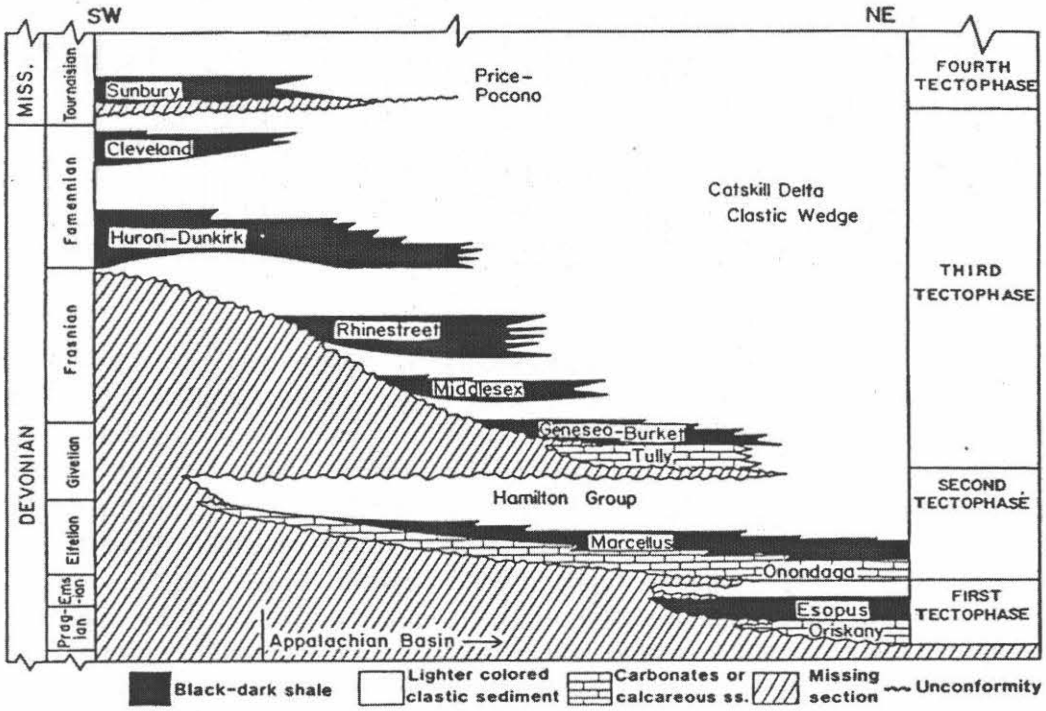

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Figure 2. A. Idealized east-west cross-section and depositional model through the Catskill Delta complex. From Broadhead et al. (1982). **B.** Stratigraphic transect showing lithostratigraphic units in an inferred flexural foreland basin setting across the Appalachian Basin. From Ettensohn (1994).

Herein, we will examine several component units and boundaries within the lower and medial parts of the Genesee Group in Erie County and western Genesee County (Figs. 4-9). Some of these are newly recognized owing to renewed mapping work across this area. In particular, we will focus on regional aspects of, and inferred origin of the medial Genesee North Evans Limestone and overlying Genundewa Formation (Figs. 8-14). The first part of the paper summarizes the succession of divisional Genesee units based on new stratigraphic work across Erie and western Genesee counties. The second part focuses on new discoveries in the North Evans-Genundewa-basal West River shale succession that bear on the genesis of this distinctive, time-rich interval. This paper represents a tribute to the pioneering work of Dan Sass, who, 45-47 years ago, traced the Genundewa Limestone across western New York and measured many of the sections described herein as part of his Masters Thesis project at the University of Rochester (see Sass, 1951). Dan, who served in World War II, was active in the fields of Environmental Science and Limnology and was instrumental in establishing both a Geology undergraduate major and an Environmental Studies program at Alfred University. He died this past March.

GEOLOGIC SETTING

Acadian orogenic uplift in New England and the central Atlantic region was associated with progradational developmemt of the Catskill Delta Complex which filled the Devonian foreland basin from east to west (see papers in Woodrow and Sevon, 1985; Fig 1). Catskill Delta progradation began in earnest during deposition of the Middle Devonian Hamilton Group following onset of the second collisional tectophase, but accelerated significantly during the third tectophase (Ettensohn, 1998). Not only do strata above the Taghanic disconformity thicken greatly to the east, but they also grade spectrally eastward and shoreward into variably fossiliferous neritic facies that are typically much coarser (Fig. 1).

During the late Middle Devonian, the study area was in the southern hemisphere tropics or subtropics and was covered by an epicontinental sea (Scotese, 1990). Deposits seen on this fieldtrip accumulated on the northern margin of a subsiding foreland basin that periodically expanded and deepened during phases of oblique collisional overthrusting (tectophases) associated with the ongoing Acadian Orogeny (Ettensohn, 1987, 1998). The most pronounced thrust loading event of tectophase three coincided with the onset of the deposition of the Genesee Group (Fig. 1); this flexural drowning event was also largely coincident with a major rise in sea level within T-R cycle IIa of Johnson et al. (1985). In west-central New York this deepening is expressed by lithologic change from shelf carbonates of the Tully Formation into basinal black shale deposits of the Geneseo Formation (Heckel, 1973; Baird and Brett, 2003). In western New York the Tully Formation is absent due to erosional/corrosional processes and progressively younger divisions of the Genesee Group (Geneseo Formation, Penn Yan Formation, and condensed North Evans/Genundewa deposits) are observed to successively onlap the Taghanic Unconformity, a major regional disconformity, in a westward direction (Fig. 2). This disconformity and associated detrital pyritic lag debris (Leicester Pyrite Member), separating fossiliferous neritic facies of the late Middle Devonian (Middle Givetian) Windom Member of the Hamilton Group from overlying dysoxic to near anoxic Genesee deposits (see Figs. 2, 3) will be seen at STOPS 2 and 3. In west-central New York localities, the gradational transgressive change from Tully carbonate facies into black shale of the Geneseo Formation coincides with the latest Middle Devonian (Huddle, 1981; Kirchgasser et al. 1989; Figs. 2, 3).

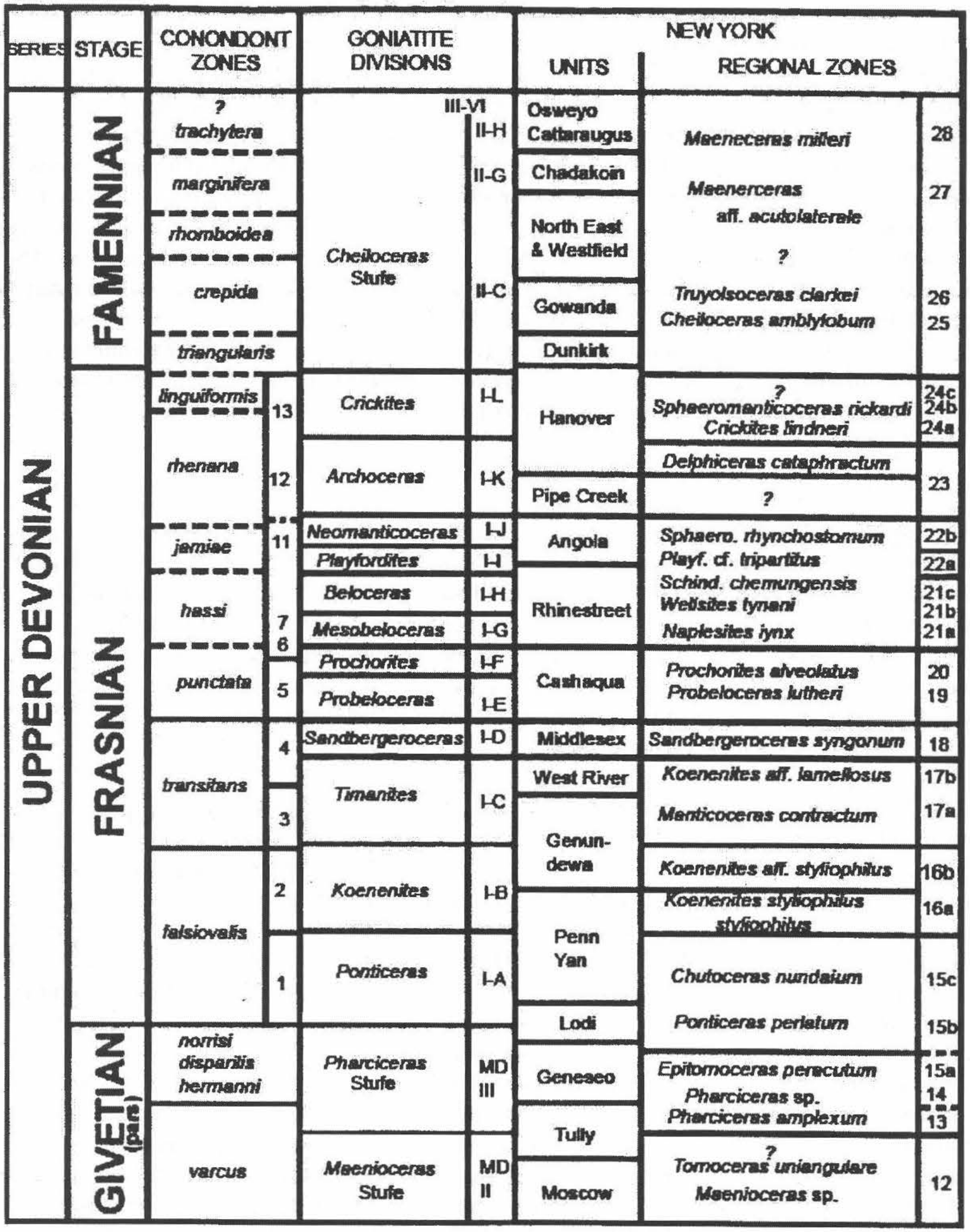

Figure 3. Late Devonian (Givetian, Frasnian and Famennian) stratigraphic succession in New York State showing alignment to international conodont zones [Standard and Montagne Noire (1-13)] and goniatite cephalopod divisions and New York regional goniatite zones (12 to 28). (Modified from House and Kirchgasser, 1993).

Proceeding westward along the Taghanic disconformity, the age of the onlapping black shale deposits become progressively younger into eastern Erie County; this reflects the regional flexural-eustatic Taghanic event (Kirchgasser et al., 1989; Baird and Brett, 1986). A younger erosion surface, associated with the North Evans conodont – bone lag below the Genundewa Limestone, oversteps the Taghanic disconformity in Erie County, thus merging the two discontinuities into a composite major unconformity (Figs. 2, 3). At STOP 1 (Eighteenmile Creek), the Late Devonian (early Lower Frasnian) North Evans Limestone rests directly on late Middle Devonian (Late Givetian) shales of the Windom Member with at least six conodont chronozones either missing or whose representative taxa are present in a range of preservations in the reworked and transported debris (Huddle, 1981, Kirchgasser et al. 1989, Kirchgasser and Koslowski, 1996, Kirchgasser, 1994, 1996, 1998, 2001, 2002, 2004). The taphonomic age of the North Evans (age when the debris came to final rest and the unit to lithification) is the upper part of Montagne Noire (MN) Zone 2, based on the occurrence of *Ancyrodella recta,* the youngest zonal indicator in the unit.

Baird and Brett (1986, 1991) discussed a variety of mechanisms capable of producing coarse traction-generated, detrital pyrite lags such as that represented by the base-Geneseo Leicester Pyrite in a deep-water, nearly anoxic regime. Processes including deep-storm wave gyre impingement, bottom current processes, and internal waves were considered as mechanisms capable of moving coarse particles at depth. We tentatively settled on a model of internal wave-shoaling against a sloped basin substrate as a possible traction mechanism; in this scenario, internal waves generated along the pycnocline, or water mass boundary, within the water column, eventually shoal against the basin margin slope resulting in erosion and sediment traction (Baird and Brett, 1991). This fits into the black shale onlap scenario in that this erosion occurs on the Taghanic disconformity slope prior to slope burial by black mud; as water deepens, owing to sea level-rise and/or flexural subsidence, the zone of pycnoclinal erosion continually migrates westward in the upslope direction ahead of black mud onlap which takes place within a lower energy, lower dysoxic substrate regime below the pycnocline (Baird and Brett, 1986, 1991). On the eastern margin of the basin, a parallel, pyrite mantled discontinuity appears in basin margin areas and dies out up-ramp into near continuity within dark gray, silty mudstone facies. Hence, erosion appears to commence earlier in the basin and migrates up-ramp in association with a rising pycnocline; such that discontinuities pass upslope to continuity beyond the highest reaches of the pycnocline during maximum highstand, a pattern opposite to unconformities generated during falling stages of sea level.

Westward flexural basin expansion during Geneseo Shale deposition would account for east-to-west slope drowning and conveyor belt-type pycnocline migration and subsequent sediment onlap across a 100 km lateral distance across western New York (Figs. 1, 2). Reworked calcareous fossils and diagenetic carbonate debris reworked from the underlying Windom Shale on the east-sloping sediment-starved Taghanic erosional ramp would start out as calcareous lag material in a shallower water wave-influenced oxygenated regime. Subsequence slope drowning with consequent overspread of dysoxic water below the rising pycnocline was postulated to explain the dissolutional transformation of the lag material to a residual placer of pyrite and other insolubles. Since the zone of pycnocline impingement was always upslope from the mud onlap limit during deposition of the Geneseo, the basal Geneseo lag would always be made up of insoluble material (Baird and Brett, 1986).

STRATIGRAPHY OF LOWER GENESEE GROUP: GENESEO AND PENN YAN FORMATION DIVISIONS

Overview

Recent mapping of the thin, stratigraphically condensed, deposits of the lower-medial Genesee Group succession (Geneseo, Penn Yan, Genundewa, and basal West River Formations) across Erie and Genesee counties has led not only to more detailed delineation of regional trends in the interval, but to discovery of new component units and erosion surfaces between units (Figs. 4-8). Generally, units thicken eastward from an extremely condensed condition in Erie County sections. Sections in southeastern Genesee County contain proportionately more gray shale relative to black shale reflecting more terrigenous influx from the east, but also reflecting better oxygenated bottom conditions than facies seen in Erie County. Westward changes from gray to dark gray shale at several levels appears to be most pronounced near Linden, on the trend of the Clarendon-Linden fault zone. Presented below is an outline description of contacts and divisions that will proceed from oldest upward.

Leicester Pyrite

The Leicester Pyrite is a detrital pyrite lag deposit that occurs along the Taghanic disconformity and, in rare instances, slightly above. This unit tracks the stages of the Taghanic onlap sequence. Typically it is an accumulation of coarse gravel-grade pyrite and pyritic steinkerns (including the goniatite *Tornoceras uniangulare)*, mostly derived from the underlying Windom Shale, that is admixed with other insoluble components such as conodonts and fish bones. Leicester debris occurs in laterally disconnected lenses along the contact; these lenses may represent erosional channels on the exposed submarine erosion surface (Figs. 4-6). Dissolution of carbonate material is usually complete owing to pervasive near-anoxia, punctuated by episodes of bottom aeration and monosulfide oxidation which periodically lowered pH levels in the vicinity of lag deposits (see Baird and Brett, 1986, 1991). We will see the Leicester Pyrite at Cazenovia Creek (Loc. 11; STOP 2) and at a tributary of Cayuga Creek (Loc. 14b; STOP 3). Localities cited in text and figures are listed in the Locality Register.

Basal black shale division of Geneseo Formation

In the Genesee and Wyoming valleys the basal 0.5-1.5 meters of the Geneseo Formation is typically hard, black, and well jointed (Fig. 6). In the Genesee Valley, several thin rusty bands in this interval may be altered volcanic ash (K-bentonitic) layers, but this is, as yet, unproven. From Linden westward, this division appears to be absent due to non-deposition prior to the Taghanic onlap (Figs. 4, 5).

Mid-Geneseo calcareous shale interval

Above the basal black shale division is a thicker interval of brown weathering, splintery to concoidal, calcareous shale that becomes more calcareous and harder towards the top of the interval (Figs. 4-6). In Genesee and Wyoming valley sections, this interval displays thicker beds near the top and is generally more calcareous overall than further west and typically holds up waterfalls in creek sections. Fossils in the interval are usually poorly preserved; key forms encountered include *Styliolina*, *Pterochaenia*, the large bivalve *Panenka*, orthoconic cephalopods, and the goniatite *Ponticeras perlatum.* The prominent limestone band with rare *P. perlatum* in about the middle of this interval in the Genesee Valley, earlier mistaken for the Lodi

Limestone (Kirchgasser, 1981), is the Genesee Limestone (Kirchgasser, Over and Brett, 1997), a unit that may be traceable to the limestone bands in the lower Geneseo in Genesee, Wyoming and Erie counties. The upper part of the calcareous shale unit is notable for pavements of a chonetid brachiopod, particularly in condensed western sections. The calcareous shale interval is capped by a regional diastemic surface that can be traced from Genesee Valley sections westward into eastern Erie County (see Figs. 4-6)). This division thins westward from approximately 8 meters in the Genesee Valley to 0.4 meter at Little Buffalo Creek (Loc. 13) in eastern Erie County. West of Linden, this interval gradually loses its calcareous aspect and becomes darker overall, suggesting more substrate dysoxia to the west.

Regional discontinuity in upper part of Geneseo Formation

Capping the calcareous shale interval from the Genesee Valley westward to Marilla, Erie County (Loc. 13), is a sharp contact that is roofed by a hard, well jointed, black shale unit (Figs. 4-6). Where this contact is well exposed, a thin, discontinuous lag of fish bones, fish scales, and conodonts can be found, suggesting that the contact is an erosion surface. The stratigraphic occurrence of this contact below the Lodi "A" and "B" beds, precludes this being part of that marker. We believe that this horizon may equate to the top-Fir Tree discontinuity within the upper part of the Geneseo Member in the central Finger Lakes region (see Baird et al., 1989; Kirchgasser et al., 1989), but this still has to be corroborated by examination of sections between Seneca Lake and the Genesee Valley as well as examination of conodonts collected from this lag surface. West of Little Buffalo Creek (Loc. 13) this contact could not be located, though a thorough search of the Buffalo and Cazenovia Creek sections was conducted.

Top-Geneseo black shale division

Overlying the upper Geneseo regional diastem is an interval of well jointed, black shale and higher interlayered black and dark gray shale deposits (Figs. 4-6). This is a division that separates the aforementioned diastem from the overlying Lodi "A" and "B" layers. If the underlying diastem is eastwardly correlative with the top-Fir Tree discontinuity, than this shale unit is correlative with the Hubbard Quarry Shale (Baird et al., 1989; Kirchgasser et al.,1989).

Lodi "A" and "B" calcareous basal divisions of the Penn Yan Formation

From the vicinity of Geneseo west to Linden at Little Tonowanda Creek (Loc. 22), two thin beds of calcareous, gray shale with small concretions in the lower bed mark the base of the Penn Yan Formation (Figs. 4-6). Baird et al. (1989) and Kirchgasser et al. (1989) mapped and delimited the Lodi Member and a coeval discontinuity within the Finger Lakes region and established a link between the Lodi in its type area at Seneca Lake and sections at and west of the Genesee Valley. Two beds are recognized in this latter area that correspond to the Lodi; a lower "A" bed of bioturbated, gray shale and irregular, calcareous nodules yielding numerous auloporid corals, small brachiopods, gastropods, the goniatite *Ponticeras perlatum* and conodonts of the late Givetian *norrisi* chronozone, and an upper "B" bed which is characterized by calcareous, bioturbated shale rich in hashy fine grained fossil debris. Both layers, separated by a thin intervening black shale unit, can be traced westward to Linden (Figs. 5-6). However, west of Linden this level is covered in sections all the way to Durkee Creek (Loc. 15) near Alden. At and west of Durkee Creek, the fossiliferous aspect of the layers is lost and the interval is a cryptic, thin unit of dark gray shale yielding *Chondrites* and *Planolites* trace fossils (Figs. 4,5).

The westward darkening of the unit accords with the darkening of the underlying mid-Geneseo calcareous interval, suggesting more basinal conditions in that direction.

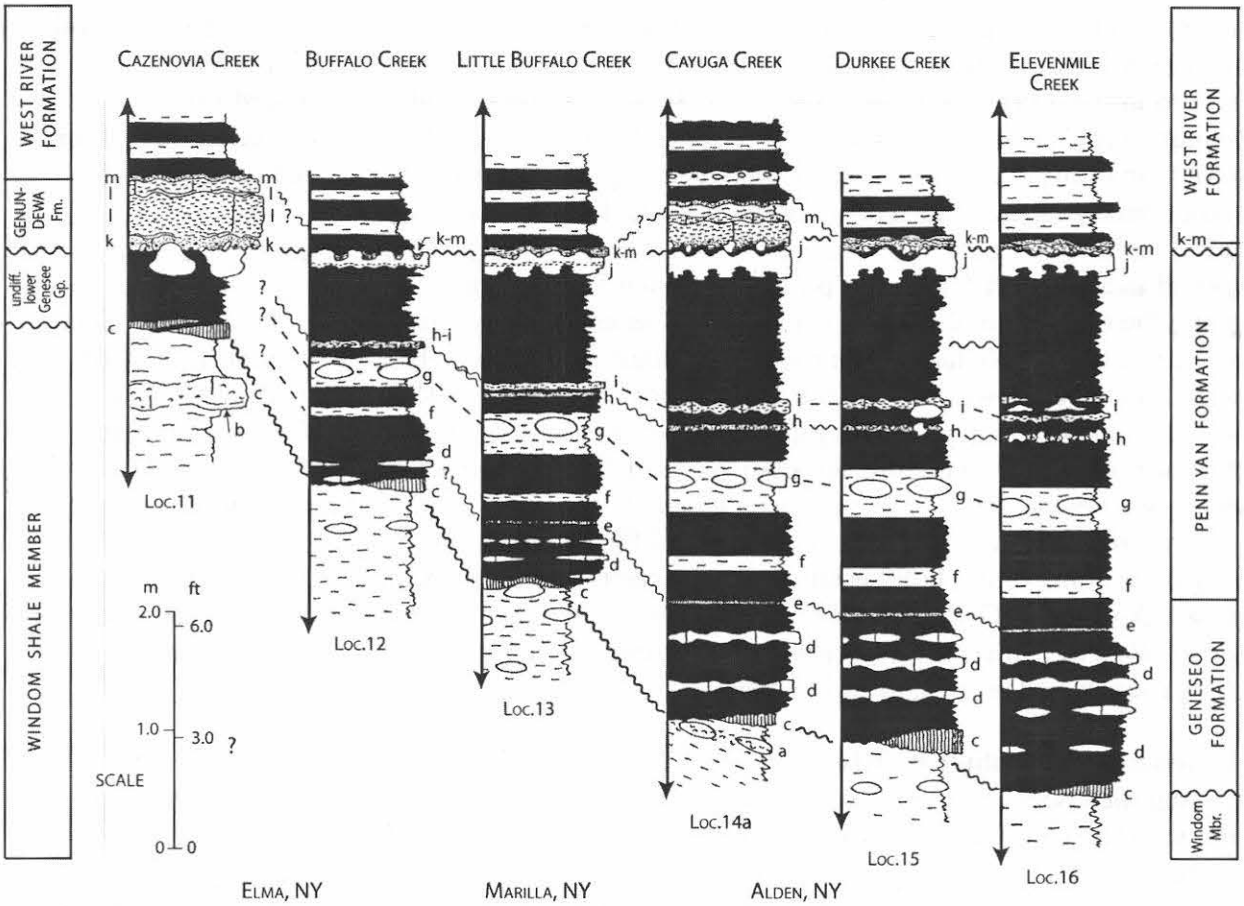

Figure 4. Lower and medial divisions of the Genesee Group; transect from Elma area, Erie County to the meridian of Darien Center. Note westward thinning of units by stratigraphic condensation to Buffalo Creek followed by accelerated westward erosional overstep of lower Genesee Group divisions by the sub-North Evans disconformity. Numbered sections are listed in Locality Register (see text).Lettered units are: a, *Pseudoatrypa – Athyris* Bed of medial Windom Member; b, Amsdell Bed of upper-middle Windom Member; c, Leicester Pyrite; d, calcareous, resistant, black-brown shale division of Geneseo Formation; e, discontinuity horizon yielding conodonts and fish bones. This may correlated eastward to the top-Fir Tree Limestone discontinuity in the central Finger Lakes region (see text); f, very dark gray, fissile shale unit probably correlative with the Lodi Limestone; g, band of large discoidal concretions in dark gray shale interval; h, discontinuity horizon yielding conodonts, fish bones, and reworked concretions. This correlates eastward to the Linden Bed (see text); i, eastwardly splaying bundle of styliolinid and micritic limestone beds and lentils herein informally designated the *Elevenmile Creek Beds*;j, zone of large, irregular, sculptured concretions herein informally designated the *grotesque concretion layer*; k, North Evans lag horizon; l, Genundewa Formation upper division ledge of styliolinid limestone; m, thin styliolinid-rich, hashy limestone bed yielding numerous conodonts and glauconite grains. This may correlate to the "Huddle Bed" horizon in the Genesee Valley (see text).

Post-Lodi black shale division

Between the Lodi "B" bed and a higher gray shale division is a black shale interval that thickens westward from the Genesee Valley into eastern Erie County. This thickening, running counter to westward overall thinning of lower Genesee units, is herein believed to reflect westward, waltherian, gray-to-black, facies change in this part of the section. In the Honeoye Lake and Canandaigua Lake region, the post-Lodi black shale division (Black Shale A) yields early forms of the conodont *Ancyrodella rotundiloba*, the taxon that marks conodont zone MN 1 and the base of the Upper Devonian Frasnian Stage (Kirchgasser et al. 1989; Kirchgasser, 1994).

Mid-Penn Yan gray shale division, concretion band, and Schumacher Bed

In the lower middle to medial Penn Yan succession, from the vicinity of Geneseo westward to Buffalo Creek in Erie County, is a persistant band of 0.3-0.5 meter diameter discoidal concretions with an associated interval of gray to dark gray, less resistant shale (Figs. 4-6). This shale unit, which largely underlies the concretion band, both thickens and becomes lighter in color eastward. It thickens from 21 cm at Buffalo Creek (Loc. 12) in Erie County, to 70 cm at Linden (Loc. 22) in the Little Tonowanda Creek Valley, and to 4.1 meters in the Genesee Valley (Figs. 4-6). From the Genesee Valley west to Linden, the top boundary of the gray shale layer with a succeeding black shale unit is marked by a styliolinid-rich and locally conodont-rich lag zone informally termed the "Schumacher Bed" (SB Bed) for a section (Loc. 26) in the Wyoming Valley (Fig. 6). In the Genesee Valley, the SB Bed yields conodonts of the early Frasnian MN Zone 1 (Kirchgasser, 1994). West of Linden no lag zone is seen at this level. From Alexander westward this contact is gradational.

Sub-Linden Bed black shale unit of Penn Yan Formation

Above the Schumacher Bed, or gray shale unit where it is absent, is a black shale interval that extends east from Erie County into the Wyoming Valley. This unit thickens eastward from 10 cm at Buffalo Creek (Loc. 12) to 85 cm at near Suicide Corners (Loc. 24) in Genesee County (Figs 4-6). East of Suicide Corners this black shale largely grades into gray shale facies in the Genesee Valley. Between the Genesee Valley and Linden this black unit grades vertically upward into a gray shale unit characterized by irregular concretions developed around a network of burrows (Figs. 5, 6). West of Linden, no gray shale or concretionary horizon can be found at this level; from Alexander (Loc. 19) west to Buffalo Creek (Loc. 12) black shale facies extends upward to the sharp base of the Linden Bed of nodules or its coeval discontinuity (Figs. 4, 5). The rapid westward loss of the gray shale unit and irregular concretions west of Linden cannot be fully explained at present. However, several units notably darken westward across this meridian; we postulate that this may be somehow linked to early activity along the Clarendon-Linden Fault Zone which runs north-south along the valley of Little Tonowanda Creek in this area.

Linden Bed and coeval diastemic contact

Extending from Little Tonowanda Creek north of Linden (Loc. 22) westward to Murder Creek southeast of Darien (Loc. 17) is a conspicuous band of very irregular, often turnip-shaped concretions that contain complex internal laminae of concentrated *Styliolina* shells and abundant phragmocones of the goniatite *Koenenites styliophilus* (Figs. 5-7). This unit termed the Linden

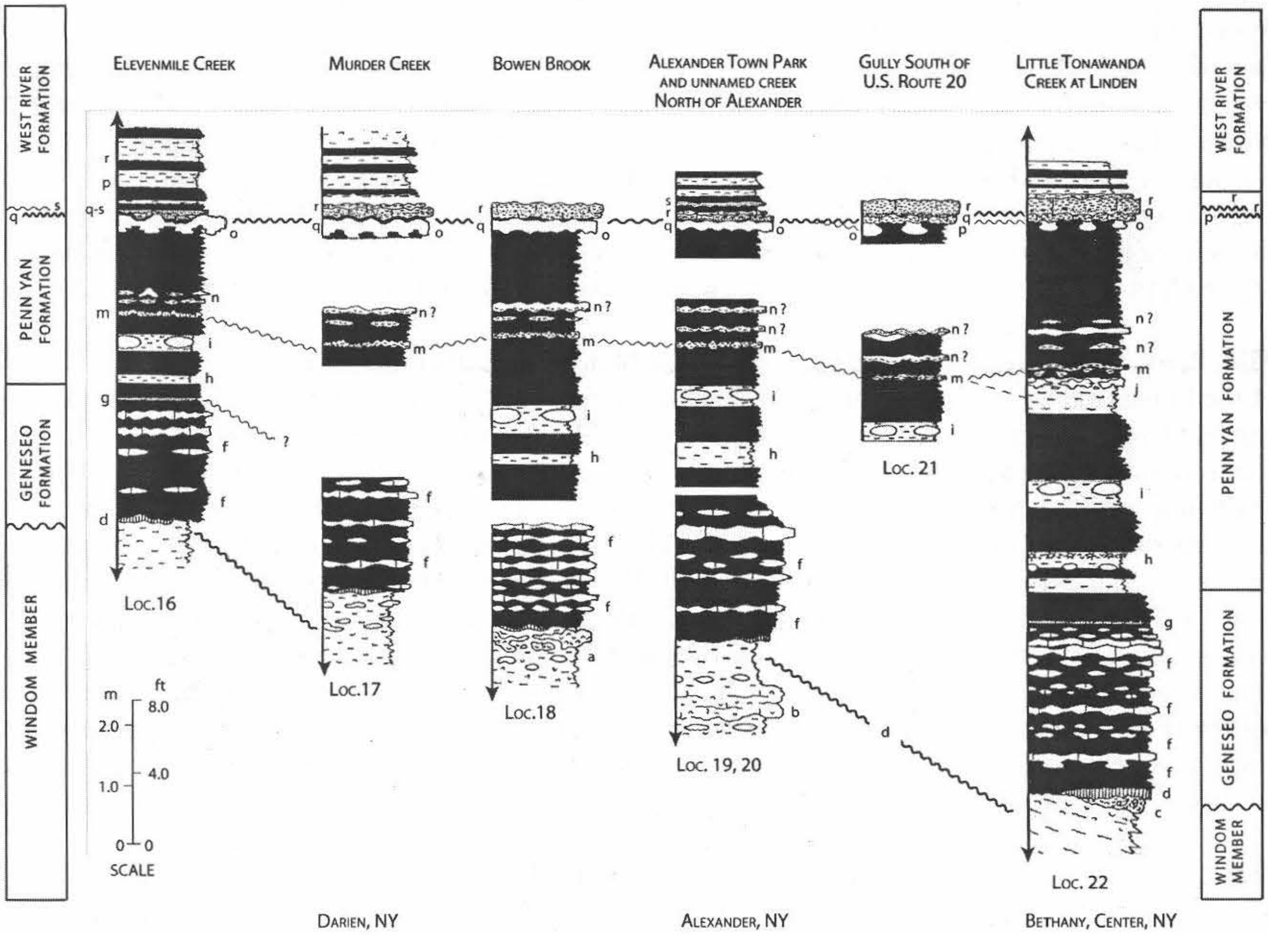

Figure 5. Lower and medial divisions of the Genesee Group; transect from the Darien Center meridian to Linden, New York. Note continued pattern of eastward expansion (splaying) of units. Numbered sections are listed in Locality Register (see text). Lettered units include: a, Bayview shell-coral Bed of Windom Member; b, Smoke Creek Bed of Windom Member; c, Fall Brook Coral Bed of Windom Member; d, Leicester Pyrite; e, Hard, black, well jointed basal shale division of Geneseo Formation; f, calcareous, resistant, black-brown shale division of Geneseo Formation; g, discontinuity horizon yielding conodonts and fish bones that possibly correlates eastward to the top-Fir Tree Limestone discontinuity (see text); h, interval eastwardly correlative to the Lodi Limestone (see text); i, band of large discoidal concretions and overlying "*Schumacher bed*" horizon of styliolinid debris; j, band of irregular concretions in gray shale not yet correlateable to sections west of Little Tonowanda Creek; m, Linden Bed of irregular *Koenenites* – bearing concretions and coeval discontinuity surface (see text); n, eastwardly splaying bundle of styliolinid and micritic limestone beds herein designated *"Elevenmile Creek beds"*; o, zone of irregular, sculptured concretions herein designated the "*grotesque concretion layer*" ; p, lower division of Genundewa Formation; q, North Evans lag horizon; r, upper division, styliolinid limestone ledge of upper division of the Genundewa Formation; s, thin, conodont- and glauconite-rich layer probably corresponding to "Huddle Bed" in Genesee Valley sections (see text).

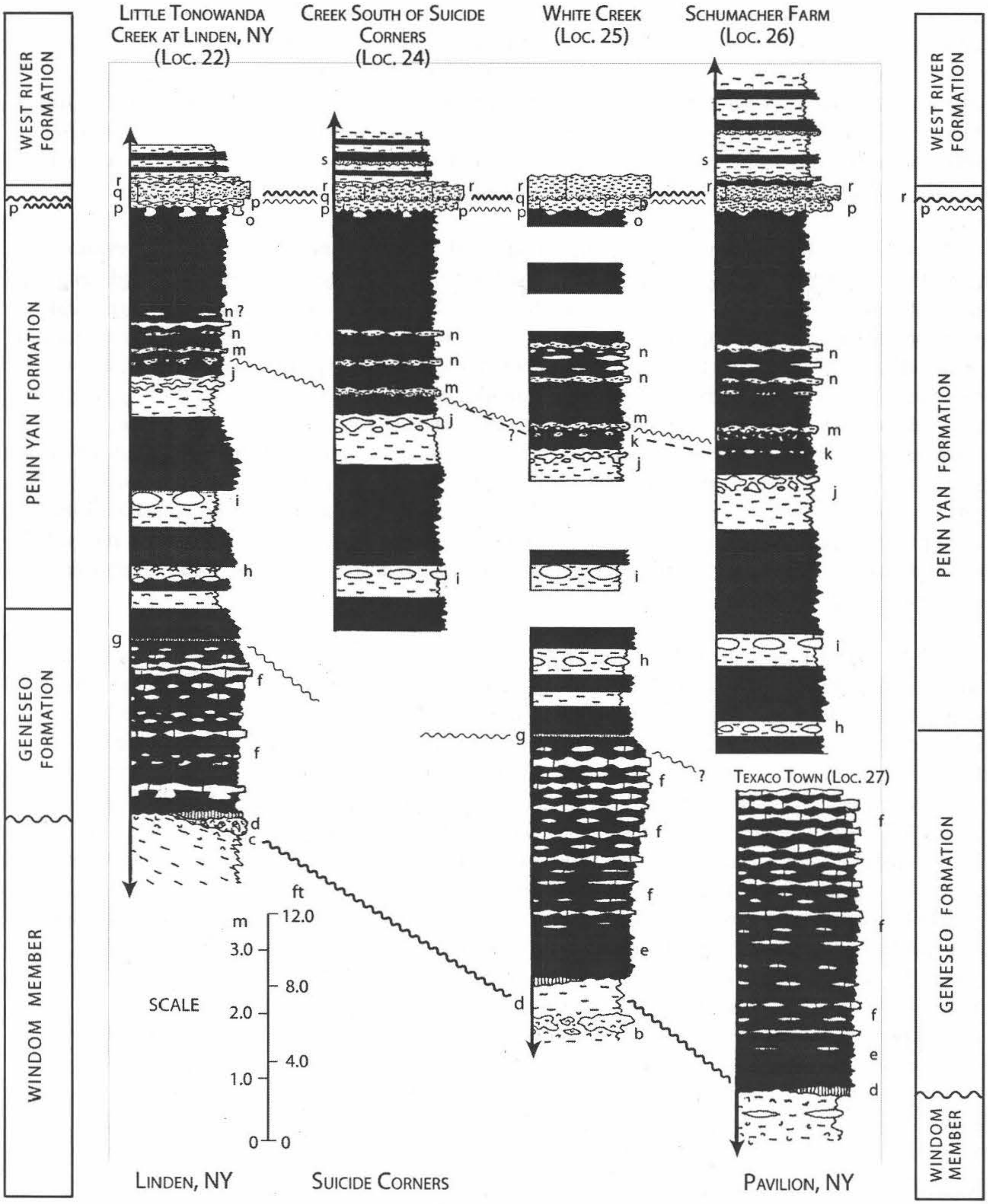

Figure 6. Lower and medial divisions of the Genesee Group along transect from Linden eastward to the vicinity of Pavilion. Note continued eastward thickening of units (see Figure 5 for key to lettered units).

Goniatite Horizon (Kirchgasser and House, 1981) and Linden Horizon (Kirchgasser, 1985) is a thin example of Cephalopodenkalk or "cephalopod limestone" long recognized by European workers (Tucker, 1974; Tucker and Kendall, 1973). It is a precursor to the Genundewa Limestone, a major styliolinid carbonate layer which is a key marker unit in the Genesee Group of western New York. Conodonts from the Linden Bed include the late form of *Ancyrodella rotundiloba,* indicating MN Zone 2 (Kirchgasser et al., 1989; Kirchgasser, 1994). New work on this unit by Baird shows that it correlates westward to a discontinuity surface (Figs. 4-7).

At Murder Creek the Linden Bed layer of cephalopod-rich limestone marks the westernmost limit of the Linden Bed (Figs. 5, 7D). At this section laterally disconnected lentils and irregular limestone masses, profusely packed with *Koenenites* phragmocones, hashy fossil debris, and secondary pyrite, show abrupt lateral margins coeval to a black shale roofed and floored diastem contact (Fig. 7D). Between the limestone masses the discontinuity lag consists of flattened *Styliolina* in association with fish bones and conodonts. The top, side, and basal margins of the limestone masses are irregular and pitted. Moreover, molds in the shape of *Koenenites* phragmocones within the limestone masses that are connected to the exterior are filled with black shale (Fig. 7D). This indicates that the Linden Bed at this locality is a residual corrosional remnant of a more nearly continuous layer. Dissolution of this limestone associated with the development of a submarine erosion surface within the basin has produced limestone remnants or "corrodules". The insoluble product of this process is represented by the bone-conodont lag concentrate (Fig. 7D).

West of Murder Creek, the cephalopod – bearing corrodules are entirely absent at this horizon, and a black shale-on-black shale erosional contact is developed west to Little Buffalo Creek (Loc. 13) northwest of Marilla (Figs. 4, 7). A thin 1-6 mm-thick lag blanket composed of flattened *Styliolina* in association of bone-conodont debris marks this disconformity at Elevenmile Creek (Loc. 16) and Durkee Creek (Loc. 15; see Fig.4). Reworked concretions typically displaying pyrite suffused corroded exteriors also occur at this level in these same sections (Fig. 7C). At Cayuga Creek (Loc. 14a), the tributary to Cayuga Creek (Loc. 14b; STOP 3), and Little Buffalo Creek (Loc. 13), reworked concretions are largely absent and the contact is marked by a subtle bedding plane reentrant within a fissile black shale interval (Figs. 4, 7B). At Buffalo Creek (Loc. 12) minor erosion beneath a higher styliolinid limestone layer has resulted in the juxtaposition of the limestone bed onto the Linden Bed discontinuity (Figs. 4, 7A). The base of this 2-3 cm-thick limestone layer is marked by abundant fish bones, fish scales, and conodonts (Fig. 7A). West of Buffalo Creek the Linden Bed discontinuity horizon is overstepped by the younger top-Penn Yan disconformity and it is absent at Cazanovia Creek (Loc. 11), the next section to the west of Buffalo Creek (Fig. 4).

East of Linden the correlations of this unit are more uncertain. Near Suicide Corners (Loc. 24), the cephalodod-rich, turnip-shaped Linden Bed nodules seen at Linden appear to be missing, though they may be reworked into an overlying *Styliolina* – rich limestone bed (Fig. 6). At White Creek (Loc. 25), the next section to the east, abundant concretions can be seen to be reworked into the aforementioned overlying styliolinid-rich layer, but smooth, *in situ* concretions rich in *Koenenites* can be seen immediately below this contact (Figs. 6, 7F). At a creek on the Schumacher Farm southwest of Pavilion (Loc. 26), the Linden Bed seems to have begun its eastward expansion with increased vertical differentiation of component beds and nodule layers (Fig. 6).

Black shale unit above Linden Bed

Between the Linden Bed and an overlying bundle of styliolinid-rich and micritic limestone layers, herein informally designated the "*Elevenmile Creek Beds*" division, is a fissile black shale interval marked by abundant *Pterochaenia* and flattened *Styliolina* at its lower contact with the Linden Bed or its coeval diastem. This division thins westward from 60 cm at Schumacher and White creeks, 23 cm at Alexander, 11 cm at Cayuga Creek tributary (STOP 3), and 2 cm at Little Buffalo Creek (Figs. 4-7). At Buffalo Creek (Loc. 12), the next section west of Little Buffalo Creek (Loc. 13), this black shale unit is missing due to overstep by a condensed limestone unit representing the local expression of the overlying Elevenmile Creek Beds division (Figs. 4, 7A,B).

"Elevenmile Creek Beds"

From Buffalo Creek east into the Canandaigua Valley is an eastwardly thickening bundle of micritic and styliolinid-rich limestone beds and lentils, herein informally designated *"Elevenmile Creek Beds,"* which markedly splay within the upper Penn Yan clastic wedge of the western Finger Lakes region. Our concern here is with correlations within this interval from the Wyoming Valley westward. Sections through this interval in the Genesee Valley and further east are thick and complex necessitating future correlation work in that area. At Buffalo Creek (Loc. 12), this division is represented by a condensed 2-3 cm-thick styliolinid-rich limestone bed that is erosionally juxtaposed onto the Linden Bed discontinuity (Fig. 7A). Proceeding east from there this bed differentiates into a complex of closely-spaced beds and lentils in the Alden-Darien area (Figs. 4, 5). Continuing east, these layers splay into more widely-spaced tabular ledges of variably stylioline-rich micritic limestone in the Little Tonowanda and Wyoming valleys (Figs. 5, 6). As such, this division thickens eastward from 2-3 cm at Buffalo Creek, 12 cm at Elevenmile creek (Loc. 16), 30 cm at Alexander (Loc. 19), and 78 cm at Schumacher Creek (Loc. 26) in the Wyoming Valley (Figs. 4-6). The interval appears to encompass several meters thickness in the Genesee Valley but this has not yet been confirmed. In the section at Linden these styliolinid bands yield shells of the small discoidal goniatite *Acanthoclymenia,* the lowest occurrence of this genus in the region.

Upper Penn Yan black shale division

Above the Elevenmile Creek Beds division is an interval of very black, fissile shale that extends nearly up to the top-Penn Yan disconformity marked by the North Evans Limestone or the lower division of the Genundewa Limestone (Figs. 4-6). Included within the upper part of this black shale unit is a continuous to discontinuous band of large concretions herein informally termed the *"Grotesque Concretion Layer."* Because these concretions appear to be linked to the development of the top-Penn Yan disconformity, they are here treated as a separate division. The black shale division, inclusive of the Grotesque Concretion Layer, thickens eastward from 66 cm at Buffalo Creek, 103 cm at Elevenmile Creek, to 2.0-2.2 meters in the Linden-Pavilion area (Figs. 4-6). Near the top of this interval, within the zone of the Grotesque Concretions in Erie County sections, is a bed of concentrated *Styliolina* that appears to have had some control on the pattern of concretion growth.

Top-Penn Yan layer of Grotesque Concretions

Just beneath the North Evans lag deposit and coeval Lower Genundewa Formation division is a band of large bulbous to complexly tiered, continuous to discontinuous concretions that occupy

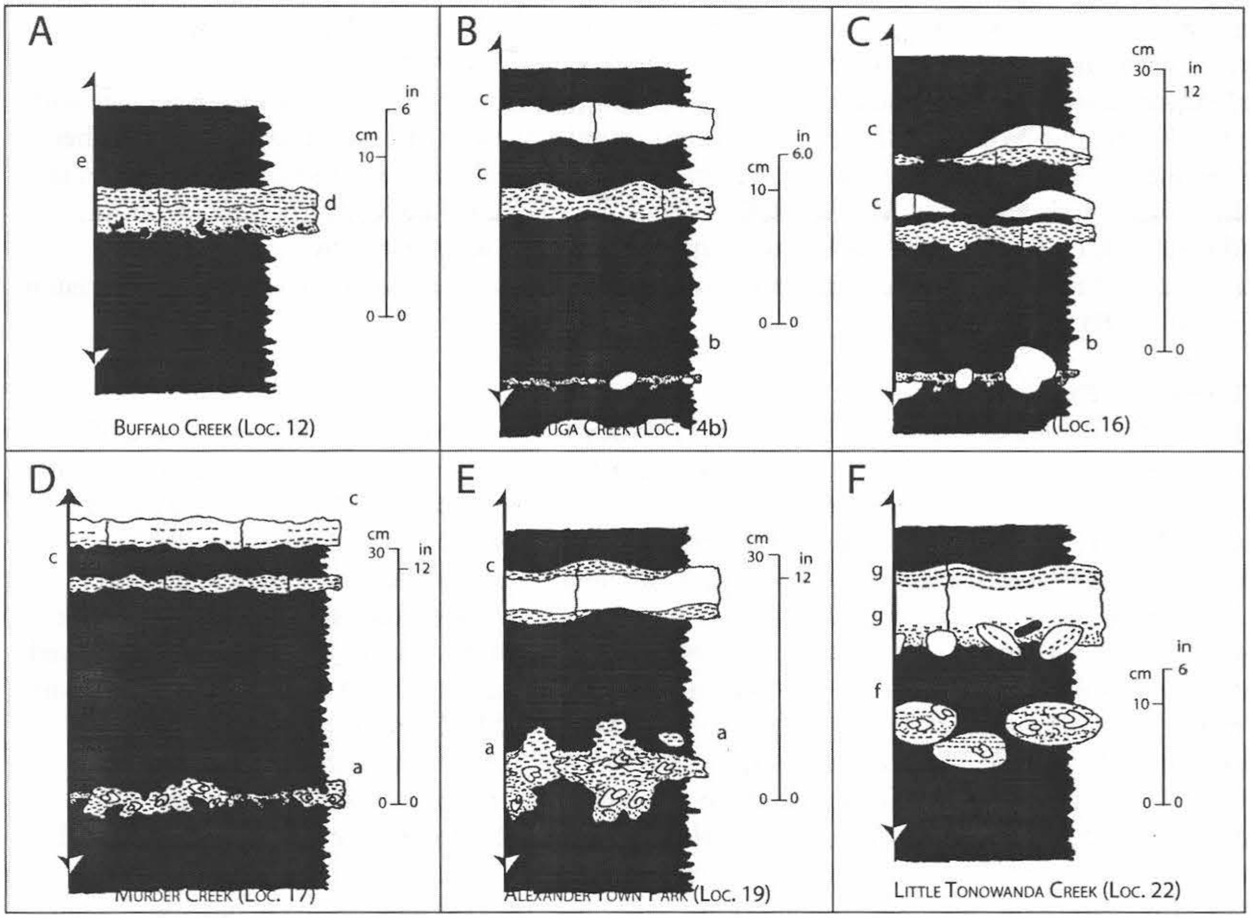

Figure 7. Pattern of westward condensation and corrosional destruction of the Linden Bed of irregular, *Styliolina* – and *Koenenites* – rich limestone nodules to form a black shale-on-black shale discontinuity. Sections D-E show westward condensation and corrosion of the Linden Bed; sections A-C show the discontinuity coeval to the Linden Bed; section F shows a problematic section east of the Linden Bed type section (see discussion in text). Numbered localities are listed in Locality Register (see text). Lettered units include: a, Linden Bed of irregular cephalopod-bearing nodules. This unit has undergone severe corrosion at Murder Creek (section D) to produce laterally separated, etched "corrodules"on a discontinuity surface; b, discontinuity coeval to Linden Bed. This is locally characterized by abundant reworked concretions; c, Elevenmile Creek Bed (bundle of styliolinid and micritic limestone beds); d, conodont-bone rich lag on compound discontinuity where overlying Elevenmile Creek Bed is juxtaposed onto the Linden Bed-equivalent discontinuity surface; e, ultracondensed Elevenmile Creek Bed which is erosionally juxtaposed onto discontinuity coeval to Linden Bed; f, *Koenenites* –bearing concretions possibly equivalent to the Linden Bed; g, Styliolinid limestone unit with lag deposit at base which also may be equivalent to the Linden Bed (see text).

the topmost part of the upper Penn Yan Shale division (Figs. 4-6). These black concretions are locally in contact with the post-Penn Yan carbonate units, but often are separated from the North Evans and Genundewa by a thin parting of black shale. The concretions are most prominently displayed and continuous in Erie County sections; they become thinner and more discontinuous eastward across Genesee County (Figs. 4-6). Multiple stages of concretion growth over an extended time period are indicated by growth partings that are sometimes layered or tiered. The complex growth architecture of the concretions gives rise to the informal name *"Grotesque Concretion Layer"* given to this unit by the present authors. One concretion showed discrete interior growth bands when fragmented. Patterns of complex growth and overgrowth within concretions were influenced locally by the presence of one or more thin styliolinid limestone

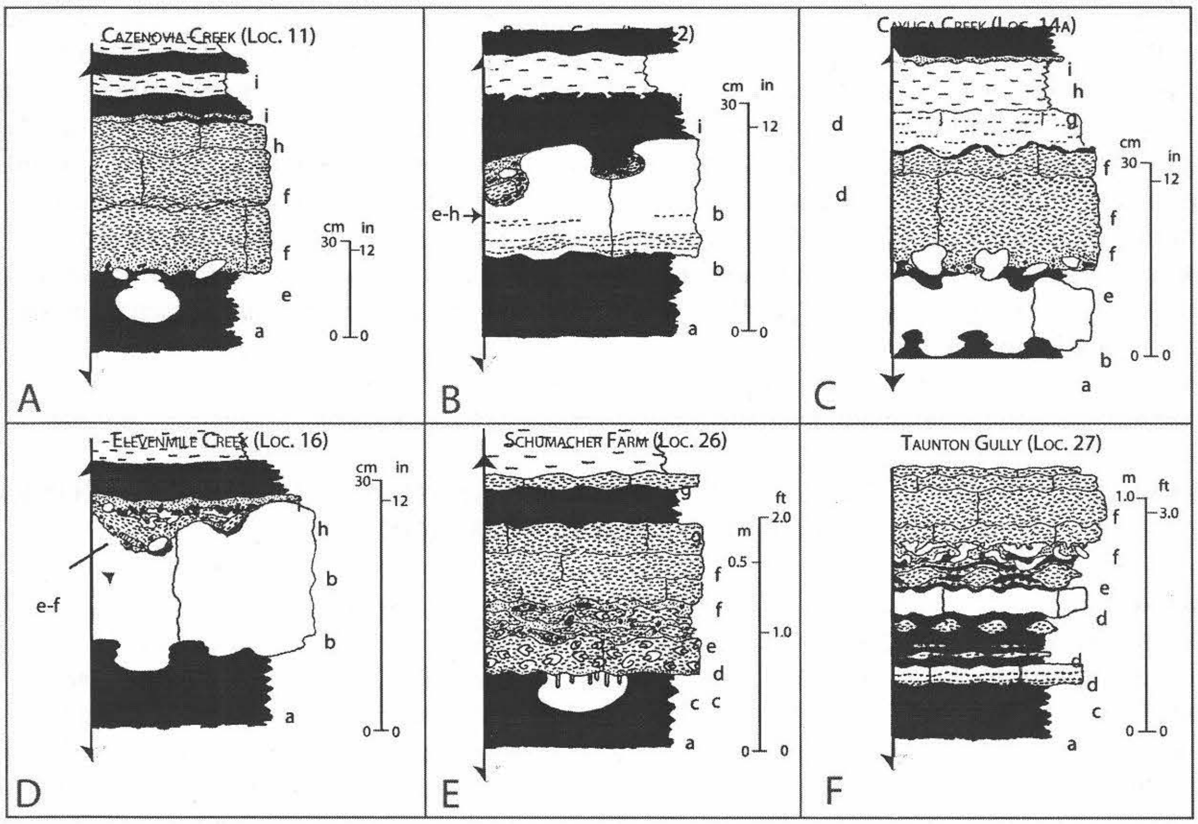

Figure 8. Genundewa Formation and associated units at several key sections (see discussion in text). Note extremely thin, lag-dominated North Evans/Genundewa deposits at Buffalo and Elevenmile creeks. Numbered localities are listed in Locality Register. Lettered units include: a, black shale division of topmost Penn Yan Formation; b, grotesque concretion layer; c, discontinuity at base of lower limestone division of Genundewa Formation; d, lower limestone division of Genundewa Formation. Note abundant goniatites in this unit at Schumacher Farm; e, North Evans lag deposit; f, upper limestone division of Genundewa Formation; g, unnamed basal division of the West River Formation; h, thin styliolinid carbonate layer in the basal West River interval which is rich in conodonts and glauconitic grains. This may correlate to the "Huddle Bed" in Genesee Valley sections (see text); i, succession of alternating black and gray shale beds within the West River Formation.

beds within the topmost part of the black shale interval in Erie County. At Buffalo Creek (Loc. 12), there is evidence that the concretion band was distinctly eroded or corroded prior to final accumulation of the North Evans lag deposit; the top of the concretion band displays pits filled with lag debris (Fig. 8B). Small clay concretions having a top-, or mason jar-shape, are abundantly reworked into the North Evans from Cazenovia Creek (Loc. 11) eastward to Elevenmile Creek (Loc. 16), suggesting that concretions were forming continuously within the topmost Penn Yan black shale interval in response to the downward migration of the disconformity surface; once formed the nodules would have been eroded out to form part of the North Evans placer. From Murder Creek (Loc. 17) eastward to the Genesee Valley few concretions are seen to be reworked. However, some erosion and exposure of preformed concretions in this zone is evidenced by the presence of open borings of the ichnogenus *Trypanites* into the top surfaces of *in situ* concretions which are in direct contact with the overlying Genundewa. The grotesque concretion horizon is, thus, viewed as having an *underbed* origin; its presence is integrally related to the development of the top-Penn Yan disconformity. Underbed limestones and concretion layers are believed to form through prolonged sulfate reduction and/or methanogenic activity along a stable redox boundary. Shifting of the North Evans debris blanket combined with prolonged exposure and erosion of variably dewatered Penn Yan organic – rich muds, would have been an ideal setting for such diagenesis. The irregular, undulating, base-North Evans erosion surface is a notable feature of Genundewa Formation sections in westernmost Genesee and eastern Erie counties. This "hillyness," which controls the thickness of overlying units (see Fig. 8 B,D), is believed to be due to differential cementation of the underlying Penn Yan top black shale division followed by differential compaction (dewatering) of uncemented mud both during and following the episode of grotesque concretion formation.

STRATIGRAPHY OF MEDIAL GENESEE DEPOSITS: NORTH EVANS LIMESTONE AND GENUNDEWA FORMATION

Overview

The North Evans/Genundewa succession was examined in detail from Pike Creek (Loc. 1) at Lake Erie eastward to the Wyoming Valley (Figs. 4-6, **8-9**) with the addition of a few selected sections from the Genesee Valley. The North Evans Limestone is a bone-conodont-rich lag that largely underlies styliolinid grainstone deposits of the upper Genundewa division in Erie and westernmost Genesee county sections, but which grades eastward, in part, into styliolinid – rich facies of the lower Genundewa division across Genesee and western Livingston counties. It marks the position of an internal discontinuity within the extremely condensed deposits of the Genundewa which overstep the lower Genundewa succession towards Buffalo. This discontinuity grades eastward into a condensed zone across Genesee County and closes to apparent continuity at the meridian of Geneseo. The North Evans rests on the top-Penn Yan regional disconformity and it conspicuously oversteps both the Geneseo and Penn Yan formations westward across Erie County (Figs. 4-6, 8).

The Genundewa Formation is composed of massive to nodular styliolinid limestone with distinctive fossils and sedimentary structures. The Genundewa contact with the overlying West River Formation is gradational where the section is expanded. However, an overlying subsidiary lag unit and associated diastem within the basal West River shale appears to overstep the North

Evans/Genundewa succession locally where local structure or bathymetric paleorelief produced extreme condensation and erosive telescoping of medial Genesee deposits (Figs. 4, 8, 9-14).

Lower Genundewa Formation division

In the Genesee Valley-Linden area, the overall Genundewa interval is thicker and more differentiated than it is further west. In the Wyoming and Little Tonowanda Creek valleys, the North Evans lag of conodonts and glauconite is not at the base of the Genundewa, but centered at the top of the lower third of the Genundewa succession (Fig 8E). The base of the Genundewa is probably disconformable to some extent with the underlying Penn Yan Shale in this area, as exemplified by a sharp basal contact and by *Trypanites* that extend downward into subjacent Penn Yan concretions (Fig 8E), but no major ("North Evans")-type, crinoidal-glauconitic, bone-

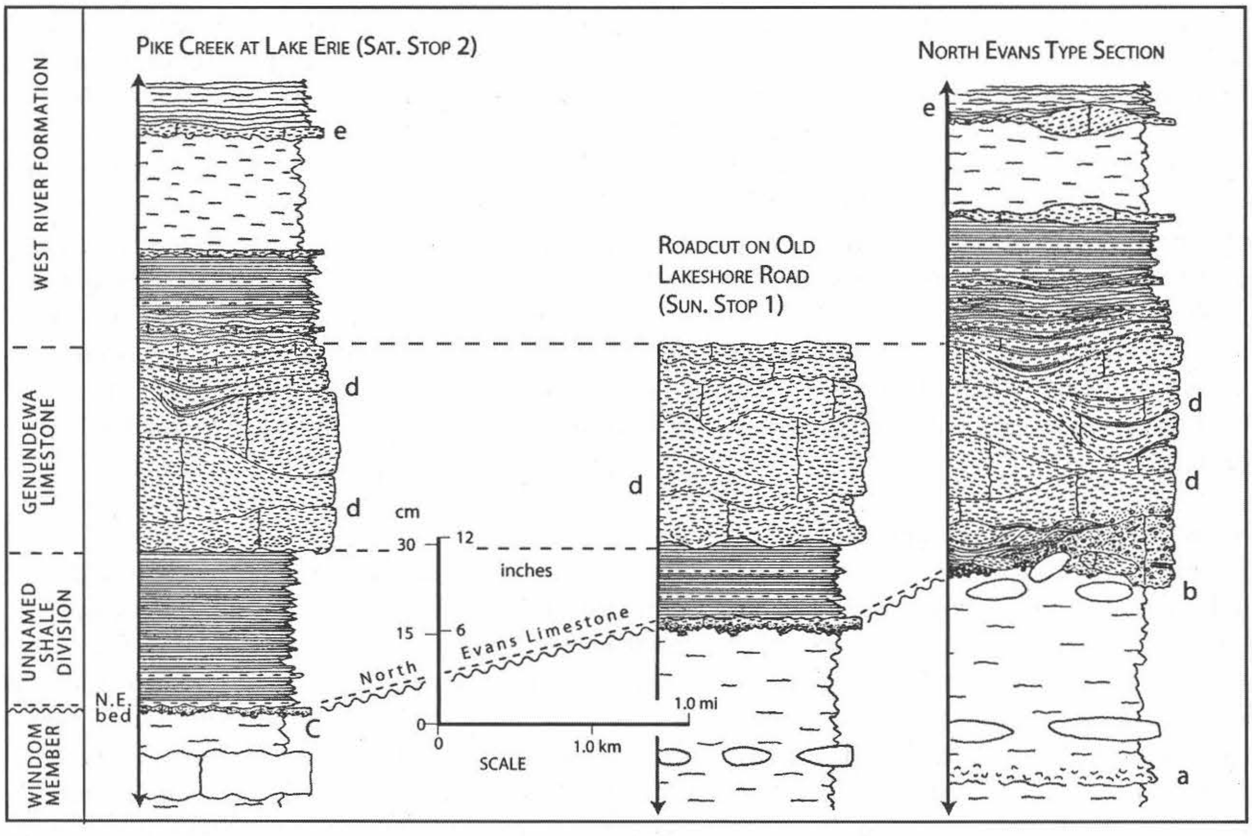

Figure 9. Genundewa Formation and associated units in sections both at and near Lake Erie in southwestern Erie County. Note westward thinning of the North Evans lag deposit from its type section on Eighteenmile Creek (Loc. 3) in association with the westward appearance of-, and thickening of, an overlying unnamed black shale unit. Note also the conspicuous bedding undulation and local channeling within the styliolinid grainstone facies of the Genundewa upper division limestone (see discussion in text). Lettered units include: a, Amsdell Bed of Windom Member; b, thick crinoidal subfacies of North Evans Limestone observed by the Amtrack railroad overpass on Eighteenmile Creek (North Evans type section); c, thin, bone, detrital pyrite – rich subfacies of North Evans Limestone seen below dark shale unit; d, massive ledge of Genundewa Formation upper division limestone; e, thin, lenticular, styliolinid limestone unit rich in conodonts and glauconitic grains. This bed may correlate eastward to the "Huddle Bed" (see discussion in text).

conodont-rich lag zone is seen at its base. Typically, the basal, 15-23 cm-thick bed of the Genundewa near Linden (Loc. 22), Bethany (Loc. 23; see STOP 4: Figs. 8E, 14), and Pavilion (Loc. 26) is a styliolinid packstone-grainstone unit containing abundant goniatites including *Koenenites styliophilus* (to be described as a new subspecies), *Acanthoclymenia* genundewa and *Tornoceras uniangulare compressum* (House and Kirchgasser, 1993; in press). Along with the Linden Bed of the Linden-Murder Creek region, this bed is a prime example of *cephalopodenkalk* of European workers. We will see a classic exposure of this Genundewa subfacies at Bethany Center (Loc. 23; see STOP 4; Fig. 14). The basal Genundewa cephalopod-rich layer grades upward into 5-15 cm-thick nodular zone rich in styliolinid packstone-grainstone lentils that are surrounded by hashy, debris-rich shale partings and burrow fillings (Figs. 8E, 10, 14). This nodular interval, rich in glauconite, crinoidal debris, conodonts, and occaisional fish fragments, is interpreted to be the North Evans lag zone in this area. The North Evans discontinuity regionally oversteps the lower Genundewa division west of the Geneseo meridian such that only the North Evans lag deposit and the overlying ledge of the Upper Genundewa Division are typically seen from Elevenmile Creek westward (Figs. 8, 9, 13). In actuality the westward terminus of the lower Genundewa division is, also in part, a gradual westward transition of Genundewa facies into North Evans facies through a complex, time-rich process of extreme sedimentary condensation (telescoping) of styliolinid beds interspersed with multiple erosion events (Figs. 10, 11). In the Elevenmile Creek-Cazenovia Creek region, reworked and quasi-reworked nodules and masses of styliolinid carbonate, complexly interspersed throughout the North Evans, serve as evidence for this. At Spezzano Ravine (Loc. 28) and Taunton Gully (Loc. 29) on the west side of the Genesee Valley (Fig. 8F) the North Evans zone of reworking has largely closed with only minor evidence of reworking evident. At Fall Brook (Loc. 30), south of Geneseo, no confirmed evidence of erosion and associated North Evans facies has been observed.

North Evans Limestone and Lag Deposit

The thin North Evans blanket of lag debris was once thought to intergrade laterally eastward to the Leicester Pyrite or overlying Penn Yan Formation (Rickard, 1975). Subsequent work by Baird and Brett, 1982 showed that the North Evans could be followed along the base of the Genundewa as far east as Elevenmile Creek (Loc. 16). North Evans debris is traceable *within* the Genundewa eastward through the Wyoming Valley and tentatively to Taunton Gully (Loc. 29) near Leicester (Figs. 6, 8E, F, 10, 11, 14). As such, the North Evans marks a regional discontinuity traceable for more than 100 kilometers. Moreover, the North Evans is now seen to overstep the Leicester, Geneseo, Penn Yan, and lower Genundewa divisions westward to produce a temporally huge hiatus (Figs. 1, 10).

As with the Leicester, the North Evans is very coarse; it contains reworked glauconite coated concretions, teeth, spines, and scales of sharks and bony fish, abundant pelmatozoan debris, and a rich and famous conodont component. In Erie and westernmost Genesee counties the North Evans contains concretions derived from underlying units; from North Evans northeast to the north branch of Smoke Creek (Locs. 3-10), concretions are reworked directly from the Windom Shale (Figs. 9, 12); from Cazanovia Creek (Loc. 11) eastward to Elevenmile Creek (Loc. 16), they are derived from lower Genesee Group strata (Figs. 4, 5, 8, 10, 12, 13). Reworked concretions are often coated by a thin sheen of glauconite imparting a green color to nodule surfaces, and many show development of diagenetic pyritic halos under their surfaces.

Concretions reworked from upper Penn Yan strata (see STOP 3), often display peripheral, medial reentrants around their exteriors much like the indentation around the mouth of a mason jar or the indentation along the periphery of a yo yo. No encrusters have been seen on concretions, but some concretions show borings of the ichnogenus *Trypanites*. The North Evans is famous for its fish fauna (see Hussakoff and Bryant, 1918; Turner, 1998), but the fauna as a whole has yet to see modern taxonomic study. Ptychtodont tritors (lozenge-shaped crushing teeth) and cuspate cladodont shark teeth are common and large armored fish plates can also be found. The North Evans Limestone ("conodont bed" of Hinde, 1879) contains conodonts representing possibly seven conodont zones, an interval of possibly over two million years (scale of Kaufmann, 2006) admixed into a complex lag blanket (Bryant, 1921; Huddle, 1981; Kirchgasser and Kozlowski, 1996; Kirchgasser and Vargo, 1998; Kirchgasser, 1994, 1996, 1998,

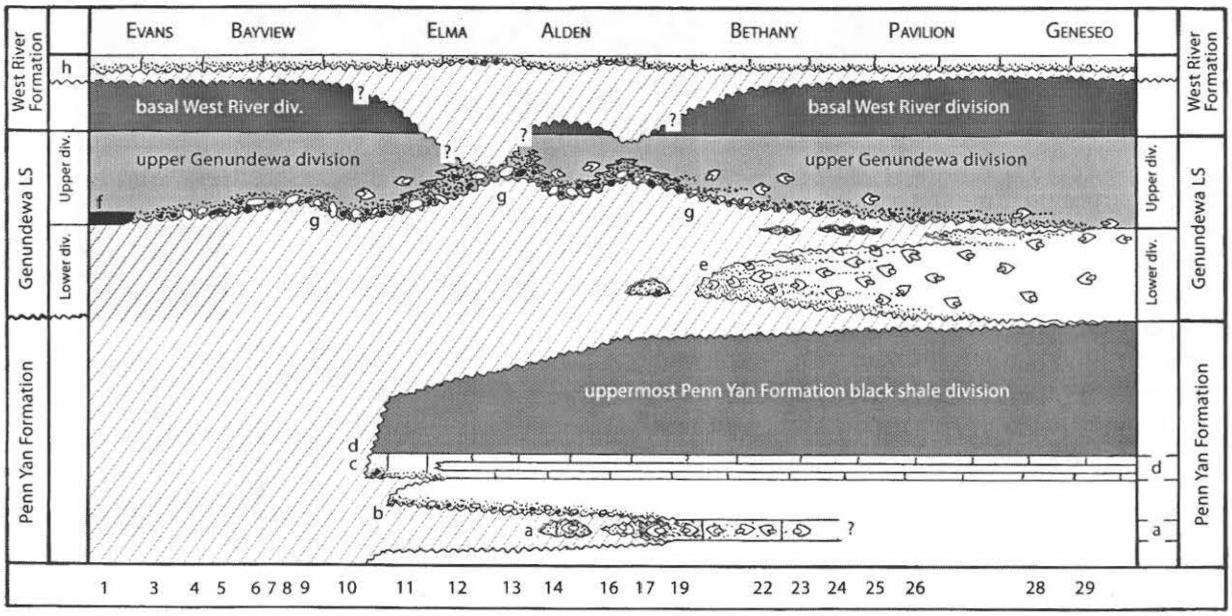

Figure 10. Inferred chronostratigraphy of medial Genesee Formation interval in western New York. Note the discovery of a discontinuity coeval to the Linden Bed, westward erosional overstep of the lower Genundewa Formation division west of the Genesee Valley, local maximal condensation of the upper Genundewa Formation division in a region of inferred basin upwarp or basin margin slope, and inferred partial-to-nearly complete truncation of the Genundewa Formation by a younger discontinuity associated with the Huddle Bed horizon in the basal West River Formation (see discussion in text). Lettered units include: a, Linden Bed; b, discontinuity coeval to Linden Bed; c, minor local diastem below westernmost condensed unit of Elevenmile Creek beds interval; d, Elevenmile Creek beds interval; e, thick North Evans lag deposit at North Evans type section that may be, in part, coeval to a localized Genundewa Formation dark shale unit ; f, local dark shale unit within upper division of Genundewa Formation near Lake Erie; g, North Evans lag deposit below Genundewa Formation upper division limestone unit; h, conodont- and glauconite-rich lag deposit in basal West River Shale that may be equivalent to the "Huddle Bed" in Genesee Valley sections. Numbers at base correspond to numbered localities listed in Locality Register.

2001, 2002, 2004). The taphonomic (final burial) age of the North Evans Limestone correlates to the upper part of early Frasnian MN Zone 2, indicated by *Ancyrodella recta,* the youngest conodont in the mix. The North Evans, as with most lag beds, poses a depositional paradox; even though the lag content records an enormous span of time, the actual final depositional event producing the bed may have been geologically instantaneous.

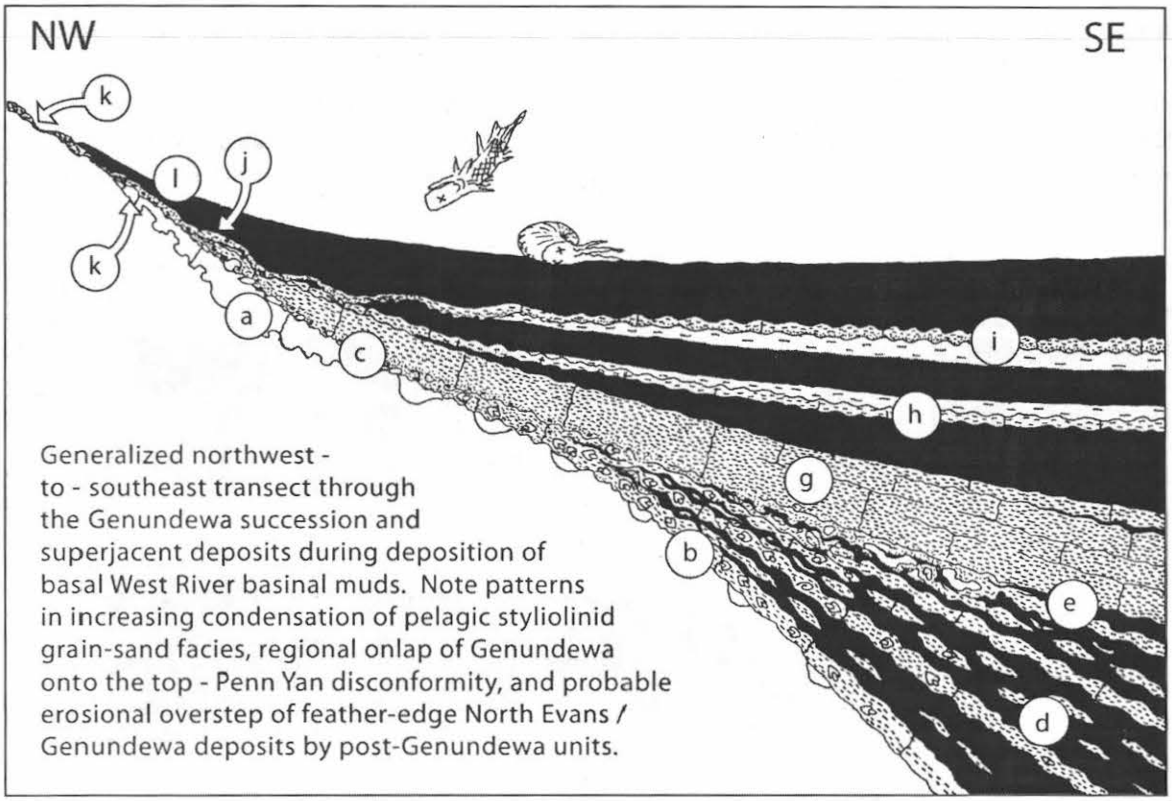

Figure 11. Generalized inferred transect of Genundewa Formation divisions normal to depositional strike, based on regional stratigraphic trends (see text). Paleoenvironment is that of basinal, near anoxia timed with accumulation of West River black muds following Huddle Bed lag accumulation. Lettered units include: a, grotesque concretion layer; b, discontinuity at base of Genundewa Formation lower limestone division; c, North Evans lag deposit; d, Genundewa Formation strata temporally equivalent to North Evans lag facies in Buffalo area sections; e, inferred basinward (downslope) limit of North Evans erosion and absence of North Evans lag debris; inferred upslope erosive overstep of grotesque concretion layer; g, *Styliolina* grainstone blanket corresponding to the Genundewa Formation upper division limestone; h, post-Genundewa styliolinid limestone bed which merges downward onto the Genundewa towards the inferred basin margin; i, Huddle Bed lag layer which converges downward into condensed Genundewa Formation facies and eventually oversteps it (see j) north of the present-day Genundewa outcrop margin; k, "Leicester –type detrital pyrite lag accumulating on the lower West River-age basin margin erosional slope surface (north of the present-day Genesee Group outcrop margin); l, inferred northwestward onlap of West River basinal mud over the erosion surface and burial of pyritic lag material (see discussion in text).

The important difference between the North Evans and Leicester is the dominantly carbonate nature of the former and the overwhelmingly insoluble character of the latter. We believe that the North Evans lag accumulated under conditions that were less dysoxic and, by implications, shallower than those applying to the Leicester. In essence, the North Evans lag is what the Leicester may have looked like at an upslope position on the Taghanic sediment-starved, erosional ramp prior to its subsequent dissolution at greater depth (Brett and Baird, 1982; Baird and Brett, 1986). At STOP 1, we will see a variant of the North Evans that more closely resembles the Leicester owing to the presence of a localized black shale unit that closely overlies it at the southwesternmost limit of its outcrop by Lake Erie (Fig. 9). In this area, North Evans lag debris was exposed to more severe dysoxic conditions than elsewhere; it is distinctly more pyrite-rich at its base and is greatly reduced in volume.

Upper (post-North Evans) division of Genundewa Formation

The Genundewa Formation upper division is usually expressed as a 18-40 cm-thick, waterfalls-capping ledge of dark gray, styliolinid grainstone-packstone carbonate. It is regionally widespread (Figs. 1, 4-6, 9-10, 12-14), but is nearly absent or greatly thinned at four localities in eastern Erie County and westernmost Genesee County (see Figs. 4, 5, 8, 10). The Genundewa upper division ledge roughly corresponds to the original *"Pteropod Limestone"* of Grabau (1898-1899) and other early workers who studied this unit in Erie County and who ascribed its component enigmatic microfossil to a group of planktonic marine mollusks known as pteropods. *Styliolina fissurella* is a problematic, 1-2 mm-long, calcareous conical shelled organism of uncertain affinities. It was originally described erroneously from flattened material, hence the specific name "*fissurella*" (Hall, 1843, 1879). Subsequent workers placed these organisms in a variety of groups; initially pteropod mollusks, later tentaculitids, and most recently protista (see Lindemann and Yochelson, 1994; Lindemann, 2002). The astonishing abundance of this taxon in the Genundewa Formation overall constitutes a major regional bioevent, or *epibole*; this organism appears to have been a form of extinct plankton that must have undergone periodic "blooms" in the epicontinental sea. In the Genundewa, these shells are uncompressed and are sometimes replaced or casted by pyrite. Although this unit is volumetrically almost entirely composed of *Styliolina,* other fossils, including the diminutive bivalve *Pterochaenia* and rare goniatites, including *Acanthoclymenia* and *Manticoceras,* first occurrence of this key genus in New York, can be found at its top. Crinoid ossicles and wood debris are also locally common in this unit. The conodont fauna of the upper Genundewa division includes *Ancyrodella rugosa* indicating MN Zone 3 (Kralick, 1994). The biota is of low diversity and suggests a dysoxic stressed environment, particularly, when compared to the rich, high diversity benthic fauna of carbonate units in the underlying Hamilton Group. Devonian styliolinid limestone facies is also known from European and North African sections where it is understood to represent condensed pelagic facies which accumulated in sediment-starved settings on the order of tens to hundreds of meters of water depth (see Tucker and Kendall, 1973; Tucker, 1974; Bandel, 1974). The Genundewa Formation overall compares most closely to the "cephalopodenkalk" (cephalopod limestone) facies of the German Rhenohercynian region; this carbonate accumulated on structural "highs" (schwellen) where styliolines, goniatites, diminutive bivalves, and ostracodes accumulated in a sediment-starved regime (Tucker, 1974). Basins between these swells received contemporaneous accumulation of thick shale units and turbiditic facies that yield mainly ostracodes and little else. Compared to descriptions of the Rhenohercynian cephalopodenkalk, the Genundewa notably lacks micrite and is much more nearly a styliolinid grainstone.

However, it is locally packed with goniatite phragmocones in a manner typical of many cephalopodenkalk units (see STOP 4; Fig. 14).

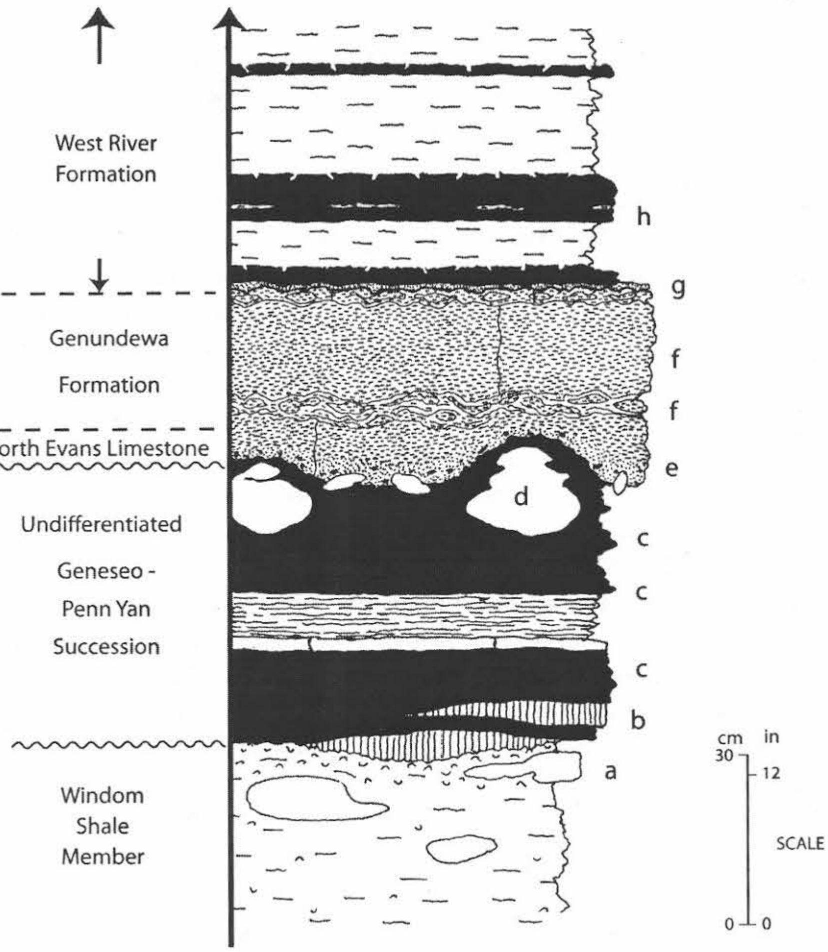

Figure 12. Genundewa Formation and associated units at Cazenovia Creek (Loc. 11; see STOP 2). Lettered units include: a, gray Windom Shale (within the Amsdell Bed interval) yielding abundant specimens of the small brachiopod *Emanuella praeumbonata* ; b, Leicester Pyrite; c, a severely truncated lower Genesee Group shale section composed of undifferentiated dark gray and black shale facies; d, large multilayered concretions corresponding to the "grotesque concretion layer"; e, pelmatozoan-rich, conodont, bone, reworked concretion and glauconite-bearing lag deposit corresponding to the North Evans lag deposit; f, upper Genundewa Formation styliolinid limestone division ledge; g, 1.0 cm-thick lag bed rich in conodonts and glauconitic grains which may correlate to the Huddle Bed in Genesee Valley sections; h, black and gray shale bed succession of the West River Formation.

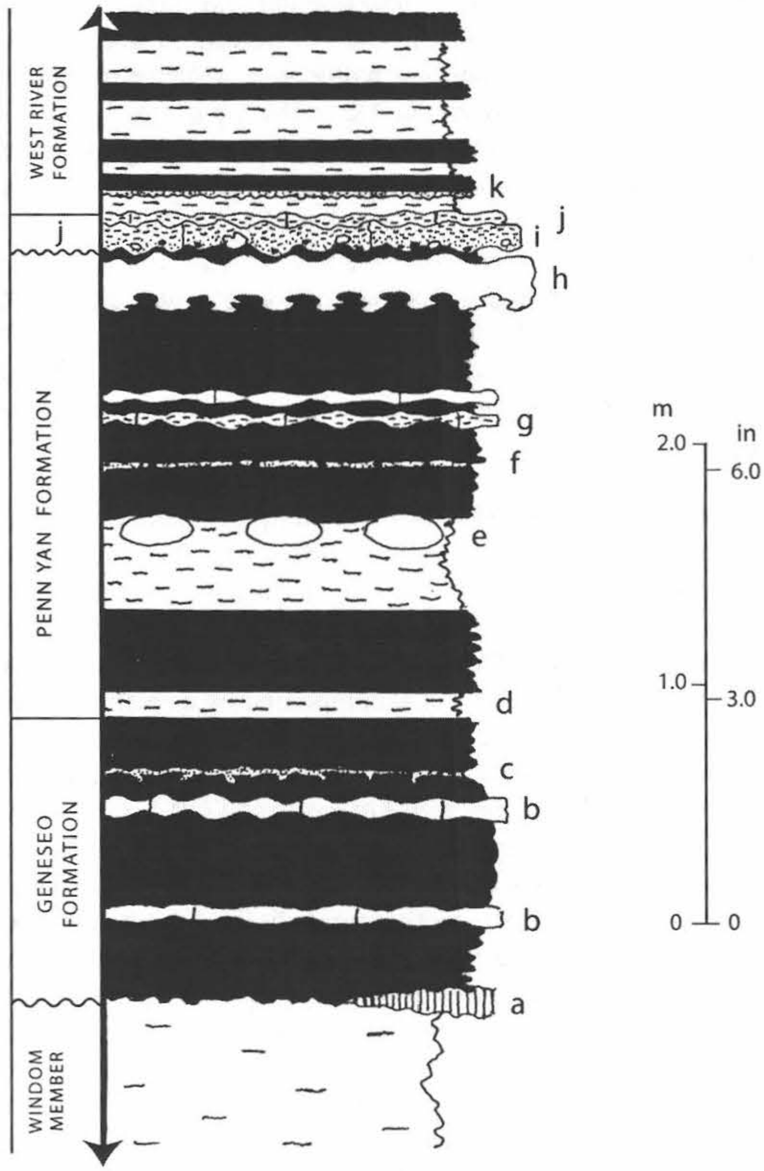

Figure 13. Lower and medial Genesee Group succession exposed on west flowing tributary of Cayuga Creek (Loc. 14b; see STOP 3). Lettered units include: a, Leicester Pyrite; b, calcareous, resistant black and dark gray shale interval of medial Geneseo Formation; c, thin styliolinid-, conodont-, and bone-rich debris layer probably correlative with the top-Fir Tree discontinuity (see text); d, dark gray shale unit probably equivalent to the Lodi Limestone interval (see text); e, layer of large discoidal concretions within dark gray shale; f, styliolinid-, conodont- and bone-rich debris layer which correlates to the Linden Bed; g, Elevenmile Creek Beds interval; h, grotesque concretion layer; i, North Evans lag deposit; j, resistant ledge of Genundewa Formation upper division styliolinid limestone bed; k, very thin styliolinid hashy limestone horizon which may correspond to Huddle Bed horizon in Genesee Valley sections (see text).

The upper Genundewa interval in Erie and Genesee counties is typically massive, but when weathered, the limestone typically splits apart into nodular and flaggy beds. Nodules occur as laterally linked to separate zones of sparry styliolinid limestone surrounded by muddy styliolinid partings. Bedding in this unit is usually laminar with some evidence of bioturbation. Goniatites are rather rare in the upper Genundewa division, but at the top of the unit at Eighteenmile Creek, small discoidal shells of *Acanthoclymenia* occur as replacements in pink barite. Preparation for both the Saturday and Sunday field trips led to discovery of distinctive cross stratification within the upper Genundewa division along the Lake Erie shore bluffs southwest of Pike Creek (Loc. 1; see STOP 2 of Saturday fieldtrip A4, this volume) and nearby on Eighteenmile Creek (Loc. 3; Fig. 9c). Several stacked sets of low angle cross stratified styliolinid grainstone can be seen with distinct thickening and thinning of beds in the cleaner, longer sections. Locally, beds are distinctly cut out where channelization has occurred. This pattern resembles small-scale hummocky cross-stratification suggesting the influence of deep-storm wave impingement at the substrate (Fig. 9a, c).

Along Eighteenmile Creek (Loc. 3) and in exposures along the Lake Erie shore (Loc. 1; see STOP 1 this fieldtrip, and STOP 2 of the Saturday A4 fieldtrip, this volume), a very localized shale unit is observed to separate the North Evans layer from the overlying ledge of the Genundewa upper division (Figs. 9, 10). This unnamed, 25 cm-thick, brownish black, flaggy shale unit contains flattened *Styliolina*, *Pterochaenia*, and wood debris. The westward appearance and thickening of this shale unit is accompanied by a reciprocal westward-southwestward thinning of the underlying North Evans Limestone (Figs. 9, 10). At the North Evans type section on Eighteenmile Creek (Loc. 3), adjacent to-, but immediately downstream from, the Amtrack railroad overpass, about four km east of STOP 1, the North Evans is a 6-12 cm thick lag accumulation dominantly composed of crinoidal debris, but also characterized by abundant conodonts, glauconitic grains, fish debris, and reworked concretions (Fig. 9c). At the overpass bridge, the North Evans grades directly into styliolinid grainstone facies of the overlying Genundewa, and no dark shale is present. However, further downstream from that bridge to the northwest, a succession of creek bank sections shows dramatic thinning of the North Evans with the appearance of the feather edge of the dark shale as a nodular parting above the lag unit. Moreover, the North Evans undergoes a lateral, spectral change from a thick crinoidal unit to a thin layer of mixed carbonate grains and detrital pyrite that is distinctly more "Leicester"- like (Fig. 9c). In the next key section (Loc. 2; Fig. 9b) along Lake Shore Road (STOP 1), the intervening shale is 10-11 cm-thick and the North Evans is only about 2-3 cm-thick. This transition from dominantly calcareous to largely insoluble grains, accords closely to the appearance of the overlying dark shale, and it suggests that carbonate dissolution of the exposed lag was more intense in the more basinal subenvironment of STOP 1 than at localities further to the northeast.

Given that this localized shale unit has a conformable (non erosional?) upper contact with the upper Genundewa division ledge with no evidence of an erosional lag deposit, we herein believe that this intervening shale unit is a local basinal subfacies of the Genundewa upper division (Fig. 10). If a significant bone-conodont lag unit were present at this horizon, we could argue for, (and test for), the idea that the local black-brown shale unit was part of the Lower Genundewa division or even the Penn Yan Formation. Evidence for an abrupt, but conformable, shale-limestone contact at STOP 1 and along the lakeshore argues against these other possibilities.

However, observation of reworked nodules of styliolinid grainstone and black shale clasts within the North Evans lag near the Amtrack railroad overpass on Eighteenmile Creek (Fig. 9c), offer the possibility that this material may be derived from the lower Genundewa division and/or underlying Penn Yan strata which are now absent due to erosional overstep.

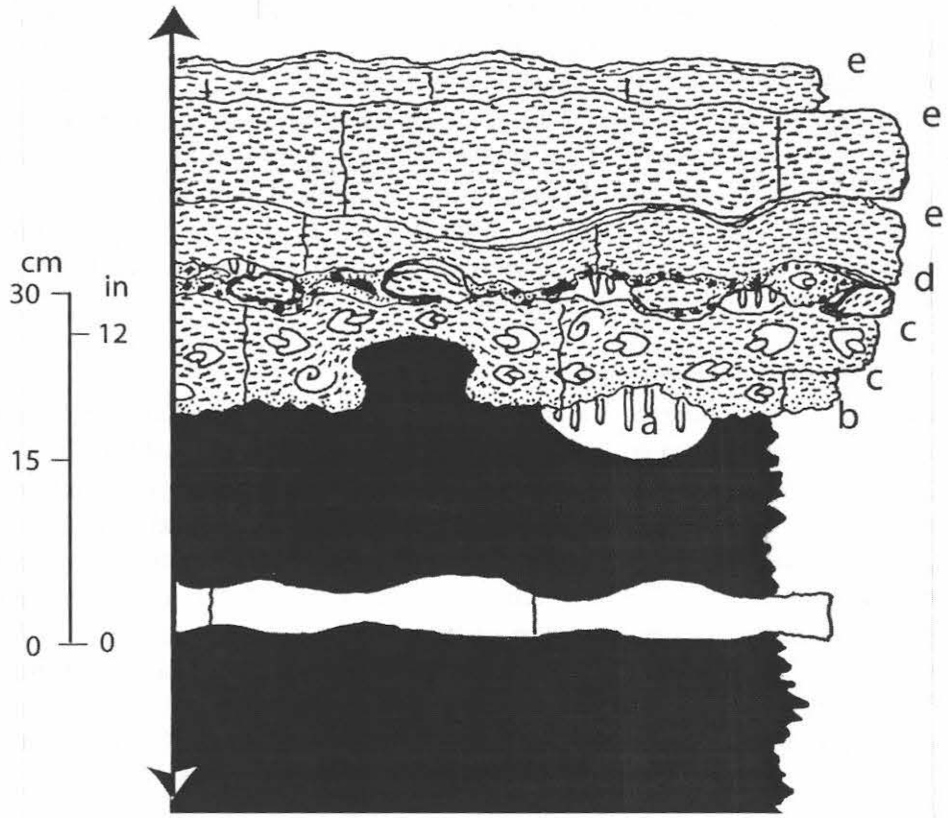

Figure 14. Genundewa Formation section in roadcut section along US 20 at Bethany, New York (Loc. 23; see STOP 4). The Genundewa is exposed below the Bethany Center Road overpass on both sides of US 20. Lettered units include: a, underbed concretion within uppermost Penn Yan Formation that corresponds to grotesque concretion layer further to the west; b, discontinuity flooring Genundewa Formation lower limestone division. Note *Trypanites* (borings) that extend downward into top-Penn Yan concretions from this contact; c, lower Genundewa limestone division showing development of classic cephalopod limestone (*cephalopodenkalk*) facies composed of styliolinid limestone with abundant phragmocones of the goniatite *Koenenites*. These can be collected easily from loose blocks on the US 20 highway berm east of this outcrop; d, North Evans interval of nodular styliolinid limestone, debris filled burrows, and thin hashy shale partings rich in conodonts and occasional fish fragments; e, resistant ledge of styliolinid grainstone – packstone facies corresponding to Genundewa Formation upper division limestone.

At two localities (Buffalo and Little Buffalo creeks) in eastern Erie County and two localities (Durkee and Elevenmile creeks) in western Genesee County (Figs. 4, 5, 8B, D), the Genundewa Limestone is very thin to nearly absent. Moreover, in these sections the Genundewa interval yields abundant pelmatozoan ossicles, fish debris, conodonts, reworked pyrite, reworked concretions, and it more closely resembles the North Evans lag facies at these places (Figs. 4, 8B, D). All four sections show a highly irregular top-Penn Yan disconformity surface directly capping, or nearly capping, the grotesque concretion layer. These depressions are filled with styliolinid carbonate complexly admixed with North Evans debris and reworked concretions whereas inter-depression "highs" are overlain by only a thin veneer of lag (Fig. 8B,D). At Buffalo Creek (Loc. 12), the most extreme condition is seen, in which North Evans-type debris-fills are observed in erosional pits excavated into the grotesque concretion bed; these pits are surrounded by inter-pit highs where the Penn Yan grotesque concretion band is directly overlain by West River black shale deposits (Fig. 8B). This is all the more notable, in that the next section to the west, Cazenovia Creek (Loc. 11), displays a thick upper Genundewa limestone succession (Figs. 4, 8A, 12). A clue potentially explaining the anomalously thin North Evans/Genundewa sections at Cazanovia , Buffalo, Little Buffalo, Durkee, and Elevenmile Creeks, is the development of a thin conodont-, glauconite-, and detrital pyrite-rich bed at the Genundewa-West River contact in all of these sections (see below).

Basal deposits of the West River Formation

From Alexander eastward into the Genesee Valley, and also in southern Erie County, the top contact of the Genundewa is gradational with the shale-dominated succession of the West River Formation (Figs. 5, 6, 8, 9-10). This is normally expressed as an upward change from massive styliolinid grainstone-packstone carbonate across one or two thinner, more mud-rich, top-Genundewa ledges, into a succession of alternating black and gray shale units that is typical of the West River Shale (Figs. 4-6, 8, 9). Generally, the West River is distinctly characterized by rhythmic black –gray shale alternations that thicken eastward and basinward as the West River thickens from 2.5-3 meters in thickness near Buffalo to approximately 22-25 meters in the Genesee Valley. This succession is marked by a few mappable layers ("Huddle Bed" conodont-glauconitic-rich styliolinid limestone layer near the base (Huddle, 1981); Bluff Point siltstone bed and associated goniatite layer in the upper middle part (Kirchgasser and House, 1981; House and Kirchgasser, 1993 and in press) ; and the Williamsburgh Bed of reworked, detrital pyrite and conodonts near the top. Herein, we will focus only on the "Huddle Bed" and a lower styliolinid limestone layer near the base of the West River succession.

At Fall Brook (Loc. 30) near Geneseo, the "Huddle Bed" is a 5-6 cm-thick bed of styliolinid limestone with a thin zone of conodont- and glauconite-rich lag debris at its base (Huddle, 1981; Kirchgasser et al., 1994, fig. 10).This unit (USGS Sample/horizon SD 8122) occurs 2.2 meters above the top of the Genundewa, and is 1.3 meters above another, lower bed of styliolinid limestone in that same section. Recent mapping by Baird shows that these beds thin and converge downward and westward towards the Genundewa as the West River succession thins due to condensation. At Spezzano Ravine (Loc. 28) on the west side of the Genesee Valley, the lower and upper styliolinid – rich limestone beds are respectively 0.6 and 1.7 meters above the Genundewa; at Schumacher Ravine (Loc. 26) near Pavilion, they are 9.0 cm and 73 cm above the Genundewa, and at a creek south of Suicide Corners (Loc. 24), the lower limestone bed has merged onto the top of the Genundewa, and the inferred Huddle Bed is only 30 cm above the Genundewa (Figs. 6, 8E). At Alexander (Loc. 19) the Huddle Bed appears to be only 8 cm above the base of the West River Shale. West of the Alexander meridian the Huddle Bed can no longer be seen as a discrete unit within the West River. In the Schumacher Creek-Alexander region the Huddle Bed is much thinner than it is in the Genesee Valley, so it could be reasonably inferred to be lost as a mappable layer west of Alexander. However, discovery of the ultra-thin North Evans/Genundewa sections at Elevenmile, Durkee, Little Buffalo and Buffalo creeks, which are all marked at their tops by a thin, conodont-, glauconite-, and detrital pyrite-rich bed, offers the possibility that the Huddle Bed is erosionally juxtaposed onto the North Evans/Genundewa deposit at these localities (Figs. 8B, D, 10, 11). The extraordinary conodont richness of this capping lag layer at these sections can be explained as due to local cannibalization of the North Evans conodont fraction by the younger sub-Huddle bed discontinuity (see Figs. 8B, D, 10, 11). A key test of these field observations will be to identify conodonts so far sampled from the putative Huddle Bed at these localities. At Fall Brook the Huddle Bed yields the conodonts *Ancyrodella recta* and *A. rugosa* indicating MN Zone 3, the presumed age of the upper division of the Genundewa Limestone in that section.

Another potential test of this idea can be accomplished by the reconstruction of this stratigraphic pattern along a different, independent transect. At Eighteenmile Creek (Loc. 3) and on the Lake Erie shore at Pike Creek (Loc.1) two outlier styliolinid beds occur, approximately 20 cm and 35 cm above the Genundewa Limestone within the basal West River Shale (Fig. 9a, c). The higher of these two beds is conspicuously marked by abundant conodonts and glauconite grains along its base, suggesting the horizon of the Huddle Bed. Proceeding northeast across western Erie County, the two beds appear to descend towards the underlying Genundewa, such that these beds are respectively 1.5 cm and 18 cm above that unit at "KB" Creek in Bayview (Loc. 6). At Cazenovia Creek (Loc. 11; see STOP 2) both beds are essentially in contact with the top of the Genundewa and would be semantically (and mistakenly) be called "Genundewa" (Figs. 4, 8A, 12). This pattern would similarly explain the drastic eastward thinning of the Gennundewa towards Buffalo Creek as being due, in part, to erosional overstep by the sub-Huddle Bed contact (Figs. 10, 11). Hence, this pattern is a mirror image of westward overstep by the sub-Huddle Bed contact to the west of Alexander (Figs. 4, 5, 10).

MEDIAL GENESEE GROUP DEPOSITIONAL TRENDS

Recent mapping in preparation of this fieldtrip paper has identified regional patterns of deposition and erosion within the Genundewa Formation and superjacent basal West River Formation succession (Figs. 10, 11). In particular, the mirror image opposing patterns of erosional overstep onto North Evans/Genundewa deposits serve to approximate depositional trends in the study area. An east-northeast trending, projected, erosional limit of the Genundewa deposit is suggested by the relationship of the broadly curving Genundewa outcrop belt east of Buffalo and patterns of condensation and erosional overstep within the overall North Evans-Huddle Bed interval (Figs. 10, 11). The trend of most abrupt lateral changes within this interval should project along a north-northwest-south-southeast transect nearly normal to the outcrop belt east of Buffalo; Figure 11 is an idealized transect across inferred paleoenvironmental strike for the eastern Erie County region. Two major processes account for the northwestward loss of the medial Genesee condensed carbonate units. The first is the overstep of the North Evans/Genundewa interval by the Huddle Bed discontinuity. The second is inferred onlap of the upper Genundewa division onto the top-Penn Yan disconformity. Just as the Geneseo Formation onlaps to near extinction onto the Taghanic disconformity (Fig. 1) the Genundewa should similarly terminate onto the foreland basin erosional slope (Fig. 11). Some of the drastic thinning of the North Evans/Genundewa interval appears to reflect this as exemplified by its localized thinning and thickening around minor irregularities on the top-Penn Yan disconformity surface that may have been produced by differential mud compaction around the underlying grotesque concretions (Figs. 8B, D). This implies that styliolinid limestone passes laterally (upslope) into North Evans facies as the erosional limit is approached (Fig. 11). It also suggests that within Genesee Formation deposits north of the present-day outcrop limit, that are now eroded away, the West River Shale would have overlain the Penn Yan Formation directly with probable development of a "Leicester-type" detrital pyrite lag deposit on the intervening disconformity (Fig. 11).

Finally, it is possible to rationally place the medial Genesee Formation succession into a sequence stratigraphic framework. The top-Penn Yan contact below the lower Genundewa division marks a lowstand event as indicated by the sub-Genundewa erosional contact and the marked facies discontinuity between the top-Penn Yan black shale facies interval below and the *Koenenites*-rich styliolinid granstone beds above. Some of the falling stage systems tract may be evidenced by a styliolinid limestone bed seen in the grotesque concretion interval of the topmost Penn Yan at some localities. The intra-Genundewa North Evans lag, of greater implied temporal significance is believed to be a hybrid sequence boundary – basin flexure generated feature; it underlies a generally transgressive interval of condensed pelagic carbonate overlain by basinal shale facies which would be consistent with a general eustatic transgressive systems tract succession. However, this spectacular lag unit appears to grade laterally to continuity within a facies of styliolinid carbonate in the Genesee Valley; this suggests only a modest lowstand event in that area, only 80 kilometers east of Buffalo. The pronounced development of the North Evans mainly in western Genesee and Erie counties suggests that localized basin margin upwarp may have been as strong an influence as eustasy in producing the North Evans lag bed. The upper Genundewa – lower West River succession is a classic transgressive interval with condensed styliolinid limestone, recording dysoxic conditions and terrigenous sediment-starvation, that is succeeded by dark West River shale that records severe dysoxia to near-anoxia. The Huddle Bed fits well into this picture as a maximum flooding surface unit recording the end of transgression and sediment-starvation and the beginning of early highstand conditions in the basin.

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LOCALITY REGISTER

Localities cited in text and illustrated in figures are listed below. Although a long succession of rock divisions may be present in many of these sections, only Genesee Group units, relevant to this study are listed in the descriptions below.

Lake Erie shore area localities (see Fig. 9)

Locality 1: Lake Erie shore bluff Genundewa Formation section south of Pike Creek (Saturday A4 fieldtrip STOP 2).

Locality 2: Genundewa Formation outcrop on Lakeshore Road opposite fishermen's parking area immediately south of Eighteenmile Creek (see STOP 1).

Locality 3: North Evans type section and overlying Genundewa and West River Formation successions below Amtrack railroad overpass along Eighteenmile Creek.

South Buffalo area localities where North Evans lag deposit is merged into overlying Genundewa Limestone as a composite limestone unit, and the North Evans directly overlies the Windom Member (not shown as figured graphic sections)

Locality 4: North Evans and overlying Genundewa limestone formation above Windom Member in creek ditch below Amsdell Road in town of Wanakah.

Locality 5: North Evans and overlying Genundewa limestone formation in abandoned quarry bordering Amtrack railroad tracks southwest of Cloverbank Road in town of Wanakah.

Locality 6: North Evans/Genundewa section on unnamed northwest-flowing stream ("KB creek") adjacent to WKBW radio mast south of Big Tree Road in the town of Bayview.

Locality 7: North Evans/Genundewa section at south edge of abandoned Penn Dixie quarry in the town of Bayview. This is now managed as a fossil park and nature center by the Hamburg Natural History Society Inc. (see Sunday fieldtrip B5, this volume).

Locality 8: North Evans/Genundewa section along New York State Thruway (roadcut along northbound lane of I-90) immediately north of Big Tree Road overpass.

Locality 9: North Evans/Genundewa section along the east fork of the south branch of Smoke Creek. Section is downstream from (west of) the California Road overpass in the town of Windom.

Locality 10: North Evans/Genundewa section on the north branch of Smoke Creek downstream from the Lake Road overpass and west of Boldt Road. .

North Evans/Genundewa sections underlain by lower Genesee Formation strata (see Figs. 4-6, 12-14)

Locality 11: Leicester Pyrite-West River Shale succession on large, east-facing cutbank of Cazenovia Creek, east of Northrup Road and 0.8 miles southwest of Springbrook (see STOP 2).

Locality 12: Leicester Pyrite-West River Shale succession on east-facing cutbank along Buffalo Creek, 0.65 mile south of Bullis Road overpass and immediately east of Iroquois High School.

Locality 13: Leicester Pyrite-West River Shale succession on Little Buffalo Creek 0.5-0.65 mile northwest of (downstream from) Bullis Road-Two Rod Road intersection in Marilla.

Locality 14a: Good Leicester Pyrite-West River Shale succession on Cayuga Creek immediately upstream from (south of) the Clinton Street overpass, 3.0 miles south-southwest of Alden.

Locality 14b: Leicester Pyrite-West River Shale succession along west-flowing tributary of Cayuga Creek, 0.2-0.35 mile west of (downstream from) Exchange Street overpass, 2.6 miles south of Alden (see STOP 3).

Locality 15: Leicester Pyrite-West River Shale succession on Durkee Creek, a tributary of Spring Creek. Section is 0.1-0.25 mile southeast of (upstream from) County Line Road-Seven Day Road junction, 2.0 miles southeast of Alden.

Locality 16: Leicester Pyrite-West River Shale succession along Elevenmile Creek, 0.1- 0.3 mile downstream from (west of) Warner Road overpass and 0.5-0.6 mile south of US 20.

Locality 17: Discontinuous Leicester Pyrite-basal West River succession on Murder Creek immediately east of hamlet of Griswold, between 0.6 and 1.0 mile southeast of Darien.

Locality 18: Discontinuous Leicester Pyrite-Genundewa Limestone succession on Bowen Brook, 0.4-0.65 mile north of US 20, 1.8 miles west-northwest of Alexander.

Locality 19: Leicester Pyrite-basal West River Shale succession on unnamed, east-flowing creek at Alexander Town Park, 0.5 mile southwest of Alexander .

Locality 20: Poor, discontinuous Geneseo Formation-Penn Yan Formation succession on unnamed southeast-flowing gully 0.6 mile north of Alexander.

Locality 21: Small northwest-flowing gully exposing upper part of Penn Yan Formation and Genundewa Limestone, 0.15 mile south of (upstream from) US 20 overpass, 2.5 miles east of Alexander.

Locality 22: Waterfall section on east-flowing tributary of Little Tonowanda creek essentially at junction of the side stream with the larger creek. Waterfall section is 0.25 mile north of a large, Genundewa Limestone-capped waterfall on Little Tonowanda Creek at Linden.

Locality 23: Genundewa Formation section in roadcut along US 20 at Bethany, NY. Outcrop is developed on both sides of US 20 beneath the Bethany Center Road overpass (see STOP 4)

Locality 24: Upper Penn Yan Formation-through-West River Shale Formation on unnamed, west-flowing tributary of Black Creek, 0.75 mile west of East Road and 1.1 miles southwest of Suicide Corners on US 20.

Locality 25: Discontinuous Leicester Pyrite-Genundewa Limestone succession on White Creek which crosses US 20 0.75 mile east of the intersection called Suicide Corners. The Geneseo and Penn Yan Formations are exposed downstream from (north of) the US 20 overpass and the Genundewa Limestone is exposed upstream from (south of) that overpass.

Locality 26: Penn Yan Formation-West River Shale Formation succession exposed on unnamed, southeast-flowing creek west of Roanoke Road and immediately upstream from the Hudson Road overpass, 1.3 miles northwest of the hamlet of Pearl Creek. Locality is on property of the large Schumacher dairy farm, hence the informal name *"Schumacher Creek"* for this locality.

Locality 27: Geneseo Formation succession exposed on small, unnamed, northeast-flowing gully, 1.25 miles southeast of the junction of routes US 20 and NY 63 at Texaco Town. Section is immediately downstream from (adjacent to) the NY 63 overpass, 0.25 mile southeast of the junction of NY 63 and Roanoke Road.

Genesee Valley outcrops cited in text but not shown as graphic sections

Locality 28: Leicester Pyrite-West River Shale Formation succession exposed along east-flowing Spezzano Ravine, 0.5 mile west of (upstream from) the NY 36 overpass, 0.75 mile southwest of the hamlet of Wadsworth.

Locality 29: Leicester Pyrite-West River Shale Formation succession along east-flowing Taunton Gully, 1.8 miles northwest of Leicester. Section is 0.0 to 0.5 mile east of (downstream from) Botsford Road overpass.

Locality 30: Classic Leicester Pyrite-West River Shale Formation succession along west-flowing Fall Brook, 1.3 miles south-southwest of Geneseo. Steep, Genundewa Limestone-capped waterfall and gorge immediately west of access car pull off just to the north of the NY 63 overpass over creek.

ROADLOG AND STOP DESCRIPTIONS

Leave the Adam's Mark Hotel in downtown Buffalo and head south to the junction with I-90. Enter I-90 eastbound towards to junction of I-90 and the New York State Thruway (I-90). The road log starts at the junction of I-190 and the Thruway where we will enter the Thruway (I-90) proceeding in the southbound direction.

Accum-ulated Miles	Incre-mental Miles	Road log description
0.0	0.0	Enter New York State Thruway (I-90) from I-190; proceed south on I-90 towards Erie, Pa.
2.0	2.0	NY 400 Expressway (overpass). Continue straight (south) on I-90.
2.45	0.45	Cross Cazenovia Creek.
3.4	1.95	Lackawanna Toll Plaza of New York State Thruway; continue straight on Thruway.
4.4	1.0	Cross south branch of Smoke Creek.
5.15	0.75	Exit to the right for NY 179 (Mile Strip Road) at the Blasdell exit of the Thruway. Pass through exit toll gate.
5.45	0.3	Junction of Thruway exit feeder with NY 179 (Mile Strip Road); turn right and proceed west on Mile Strip Road.
6.85	1.4	Junction of Mile Strip Road with NY 5. Enter (merge right) into junction rotary feeder which turns left (to south).
7.05	0.2	Exit junction rotary (to right) for entrance feeder to NY 5 southbound.
7.15	0.1	Merge into southbound NY 5. Ford plant on the left.
7.95	0.8	Fork to left for Hamburg. Bear right (straight) on NY 5.
8.65	0.7	View of Lake Erie to the right. Bluff exposure is Ledyard Member of Ludlowville Formation (Middle Devonian).
8.75	0.1	Entering town of Athol Springs. We will continue through communities of Athol Springs, Mount Vernon, and Wanakah.
12.35	3.6	Junction of NY 5 with Lake Shore Road. Bear right onto Lake Shore Road.

15.55 3.2 Bridge over Eighteenmile creek. Upstream cutbank to the left shows the Middle Devonian Hamilton Group divisions unconformably overlain by Late Devonian strata of the Genesee Group.

15.65 0.1 Turn left immediately south of Eighteenmile Creek bridge into parking lot maintained for fishermen.

STOP 1. Taghanic disconformity exposed in small cut (Loc. 2) along Lake Shore Road opposite parking area (see Fig. 9b). Exit vehicles and proceed across Lakeshore Road to roadcut slightly south of the parking lot entrance. People must watch for traffic coming down the hill around the blind corner.

This roadcut displays, in upward succession, the upper medial part of the Windom Member of the Moscow Formation (Fig. 9a), the Taghanic disconformity, a thin, local expression of the North Evans lag deposit below the Genundewa Formation (Fig. 9c), a thin unnamed and very localized dark gray to black shale unit within the Genundewa Formation, and the resistant ledge of styliolinid limestone representing the upper division of the Genundewa Formation (Fig. 9d). The disconformity below the North Evans spans possibly 7 conodont chronozones representing approximately 2 million years of geologic time (see text); units observed in the Finger Lakes region and in eastern New York (topmost parts of Moscow Formation, Tully Formation, and lower half of Genesee Group succession) are missing here such that Late Devonian strata belong to the upper part of early Frasnian MN Zone 2 are juxtaposed onto Middle Devonian beds belonging to the Middle *varcus* chronozone (see text).

The North Evans is here represented by a thin, 1-2 cm-thick lag unit rich in pelmatozoan debris, glauconite grains, a conspicuous mixed conodont fauna, and fish teeth, incuding numerous small cladodont shark teeth and rare ptychtodont tritors (Fig. 9c). Secondarily oxidized (limonitized) detrital pyrite grains are common in this mix, especially at the base. The tubular clasts represent pyritized burrows that were exhumed from the underlying Windom Shale (see text). Conodonts at the bedding-plane contact with the Windom include *Ancyrodella recta* that indicates the upper part of Frasnian conodont MN Zone 2. Above the North Evans is a 28 cm-thick fissile dark shale unit that can be accessed below the Genundewa Limestone overhang. As noted in the text, this shale is extremely local in extent, being found only in the vicinity of the Lake Erie shore (Fig. 9). Because there is no lag deposit and implied discontinuity separating the shale from the overlying Genundewa upper division limestone bed at this section and at Pipe Creek, we believe that the shale unit is a local basinal subfacies of the upper Genundewa division or a post-North Evans Genundewa division not normally expressed elsewhere (see text). The presence of the dark shale unit roofing the North Evans in this section is believed to explain, in part, the thin, pyrite-rich character of the North Evans lag deposit in sections where it is present (Fig. 9). More intense dysoxia associated with the basinal subenvironment represented by onset of black shale deposition could explain local dissolution of the carbonate fraction normally seen in the North Evans (see text). The overlying ledge of the upper Genundewa division (Fig. 9d) displays the typical outcrop character of this unit. This bed is composed almost exclusively of uncompressed *Styliolina fissurella* with accessory occurrences of the small bivalve *Pterochaenia*, wood debris, and rare goniatites, and it probably represents an offshore dysoxic regime characterized by prolonged sediment starvation and surface water productivity supporting *Styliolina* as plankton.

		Return to vehicles. Retrace route back to the junction of Mile Strip Road and the I-90 exit in Blasdell, but continue east from there on Mile Strip Road.
25.85	10.2	Junction of Mile Strip Road with the New York State Thruway exit in Blasdell; continue straight (east) on Mile Strip Road.
26.05	0.2	Mile Strip Road crosses over New York State Thruway. Continue straight (east) on Mile Strip Road.
28.95	2.9	Junction of Mile Strip Road with US 20. Turn left and proceed to the northeast on US 20.
32.75	3.8	Junction of Transit Road with US 20. Turn right (south) onto Transit Road.
33.25	0.5	Junction of Transit Road with Northrup Road. Turn left onto Northrup Road.
33.5	0.25	Pull off onto shoulder of Northrup Road just west of Cazenovia Creek.

STOP 2. Large cutbank on west side of Cazenovia Creek (Loc. 11) displaying Genundewa Formation and associated units (see Fig. 12). Exit vehicles and proceed across private driveway and yard. Continue along graded trail down to floodplain of Cazenovia Creek. Turn left (north) and follow improvise trail through tall brush to outcrop approximately 300 meters north of the base of the graded trail. The improvised trail may be wet and muddy and Cazenovia Creek may be high making examination of the outcrop difficult.

This large, clean exposure shows several units to advantage (Fig.12); these are, in ascending order, the Amsdell Bed (*Emanuella praeumbona* –rich interval) of the Windom Member (Fig. 12a), the Leicester Pyrite of the Geneseo Formation (Fig. 12b), an undifferentiated interval of black and dark gray shale corresponding to the lower part of the Genesee Group (Fig.12c), a band of laterally separated large concretions corresponding to the "grotesque concretion" level (Fig. 12d), the North Evans lag deposit (Fig. 12e), a thin zone of nodular styliolinid limestone above the North Evans comprising the lower part of the Genundewa upper division (Fig. 12f), the massive, main part of the upper division of the Genundewa Formation (Fig.12f), a thin conodont- and glauconite-bearing lag layer (Fig.12g), and the West River Formation (Fig. 12h).

This section offers an excellent opportunity to view Leicester pyrite lenses along the Taghanic disconformity if the water is not too high. These lenses (Fig.12b), laterally separated by bank intervals lacking lag pyrite, may be profiles of channel fill deposits that accumulated on the Taghanic dysoxic erosional substrate (see text). They are composed of gravel-sized grains of detrital pyrite that correspond to reworked diagenetic pyrite derived mainly from the Windom Shale. Pyritic burrow tubes make up most of the Leicester clasts, but pyritic steinkerns of orthoconic and goniatitic cephalopods, as well as fish bones and teeth, can be seen.

The black-dark gray shale succession between the Leicester and North Evans Limestone beds (Fig.12c) represents the feather edge of a much thicker Geneseo Formation succession to the east (Figs. 4-6). At the north branch of Smoke Creek (Loc. 10), four miles west of here, the sub-North Evans disconformity is juxtaposed directly onto the Windom Member.

The North Evans lag (Fig.12e) contains a mixture of pelmatozoan debris, conodonts, glauconitic grains, reworked concretions, and fish bone/tooth debris. It grades upward into styliolinid grainstone facies of the overlying Genundewa Limestone. The Genundewa is quite thick at this section; it thins dramatically eastward from here, being essentially absent at Buffalo Creek (Loc. 12), the next section to the east (see Fig. 8 A,B). The top of the Genundewa at this section is marked by a 1.0 cm-thick lag unit (Fig.12g) rich in conodonts and glauconitic grains that may link to the "Huddle Bed" diastemic horizon recognized by others (see text). This discontinuity may be, in part, responsible for erosional overstep of portions of the Genundewa Formation seen in sections east of here (see text).

Return to vehicles. Continue north on Northrup Road.

34.5	1.0	Northrup Road crosses Cazenovia Creek. This classic fossil locality can be seen to the right; the Tichenor Limestone, basal division of the Moscow Formation, holds up the low waterfall and overlies fossiliferous shale of the Wanakah Member of the Ludlowville Formation. In the distance, the high bank displays the Windom Member and overlying Genesee Group strata.
34.8	0.3	Junction of Northrup Road with NY 16/78 at Springbrook. Turn left onto NY 16/78.
35.6	0.8	Junction of NY 16/78 with US 20 in Elma; turn right (north) onto US 20.
36.4	0.45	NY 400 Expressway overpass. Continue straight on US 20.
36.75	0.35	Junction of US 20 with Bullis Road; turn right (east) onto Bullis Road and proceed toward Marilla.
41.75	5.0	Bullis Road crosses Buffalo Creek. Basal limestone divisions (Tichenor Member, Menteth Member) of the Moscow Formation visible below bridge in floor of creek.
44.05	2.3	Junction of Bullis Road with Two Rod Road at intersection in Marilla; turn left (north) onto Two Rod Road.
45.2	1.15	Junction of Two Rod Road with Clinton Street (NY 354); turn right (east) on Clinton Street.

47.85 2.65 Clinton Street bridge over Cayuga Creek. Excellent exposure of Windom Member-West River succession along creek upstream from bridge. This section (Loc. 14a) has been used for field stops in the past, but access is a problem presently. We will, instead, employ a nearby section for STOP 3.

48.05 0.2 Junction of Clinton Street with Exchange Street; turn left (north) onto Exchange Street.

48.55 0.5 Exchange Street bridge over west-flowing tributary of Cayuga Creek; pull off into driveway or road shoulder adjacent to bridge.

STOP 3. Upper Windom Member-into-West River Formation succession exposed along west-flowing tributary of Cayuga Creek (Loc. 14b; see Fig. 13). Exit vehicles and proceed west across private yard and sloped wooded area behind yard to creek bottom. Proceed left (west) down the creek to a low waterfall where the Moscow Formation-Genesee Group contact can be seen.

At the waterfall black shale deposits of the Geneseo Formation rest abruptly on the Taghanic Disconformity which caps the sloped exposure of gray Windom Shale in the falls face. Lenses of Leicester Pyrite (Fig.13a) can be spotted owing to the trail of rust seepage developed below them on the outcrop face. The Geneseo Formation is marked mainly by a calcareous black shale interval (Fig.13b) that is capped by a discontinuity (Fig.13c) characterized by comminuted fossil debris and a few fish bones and conodonts. It may correlate to the top-Fir Tree discontinuity in the Finger Lakes region, but this idea has yet to be tested (see text). Strata, probably equivalent to the Lodi Limestone interval in the Finger Lakes area (Fig.13d), are cryptic in this area; we will skip over this part of the section. However, above a band of prominent, brown weathering concretions (Fig.13e), is a black shale-on-black shale discontinuity (Fig.13f) that is marked by a pavement of flattened *Styliolina* in association with conodonts and cuspate cladodont shark teeth. This contact can best be accessed at the minor falls just above the concretion band where it occurs 12 cm below a 3 cm-thick styliolinid bed (Fig.13g) which is the local condensed expression of the Elevenmile Creek bed.This conodont-bone-rich horizon (unit 13f) is found to correlate eastward to the Linden Bed (see text).

At a third low falls lip the North Evans-Genundewa succession (Fig.13i,j) is observed to overlie a conspicuous band of irregular "sculptured" concretions herein referred to as the *grotesque concretion layer* (Fig 13h). These concretions are interpreted as underbed concretions which formed in a zone of fluctuating redox conditions below the downward migrating top-Penn Yan erosion surface; concretions of this type that formed earlier can be seen as reworked clasts within the overlying North Evans lag deposit (Fig.13i). The North Evans is well developed here and can be easily sampled. The massive, nodular, falls-capping, upper Genundewa division ledge is also well developed at this locality (Fig.13j). A thin conodont- and glauconite-rich layer, herein interpreted to be the equivalent of the Huddle Bed, is present 10 cm above the Genundewa on nearby Cayuga Creek (Loc. 14a). However, on this creek that bed is very thin and cryptic; it probably is expressed as a thin styliolinid-rich layer (Fig.13k) 12 cm above the top of the Genundewa. The West River Formation is best viewed in the north-facing cutbank section immediately upstream from the Genundewa falls. Here it consists of thin alternations of gray and black shale with a few thin siltstone beds in the upper part (Fig.13).

Return to vehicles. Continue north on Exchange Street.

49.55	1.0	Junction of Exchange Street with Henskee Road; turn right (east) on Henskee Road.
50.45	0.9	Junction of Henskee Road with Sullivan Road; continue east on Henskee Road.
51.15	0.7	Junction of Henskee Road with County Line Road; turn right (north) onto County Line Road.
51.75	0.6	County Line Road crosses Durkee Creek, a tributary of Spring Creek. This shows a complete Windom Member-basal West River Formation succession (Loc. 15). Just beyond view is the thickest Leicester pyrite lens known with a maximum thickness of about 28 cm.
52.65	0.9	Junction of County Line Road with US 20; turn right (east) onto US 20 and continue towards Bethany Center.
54.25	1.6	Junction of Harlow Road and US 20. Darien Lakes State Park visible to north. Continue straight (east) on US 20.
54.75	0.5	Bridge over Elevenmile Creek. Long Devonian section on this creek extending from the lower part of the Ludlowville Formation up through the study interval, into the Middlesex Formation. When foliage is absent, the Tichenor and Menteth members of the Moscow Formation can be seen to cap a waterfall visible from the road.
56.45	1.7	Junction of NY 77 with US 20 in Darien Center; continue east on US 20.
58.25	1.8	Cross Murder Creek in Darien. Intermittent Moscow, Geneseo, Penn Yan, and Genundewa formation sections occur along this Creek (Loc. 17).
63.65	5.4	Junction of US 20 with NY 98 near Alexander; continue east on US 20.
66.35	2.7	Bridge over Little Tonowanda Creek. The Kashong Member-Windom Member boundary is visible in the creek floor to the north of the bridge. Good Genesee Group sections are developed much further upstream near Linden. Structural dip observed in the vicinity of this creek is the local expression of the Clarenden-Linden fault zone.
69.65	3.3	Exposure of Genundewa Formation exposed below the Bethany Center Road Bridge on both sides of US 20. We will examine this section momentarily as part of STOP 3.

69.85 0.2 Turn left (north) onto Old Telephone Road from US 20. Park vehicles on right hand shoulder of Old Telephone Road immediately north of the turn off of US 20.

STOP 4. Genundewa Formation exposure (Loc. 23) on both sides of US 20 below Bethany Center Road and loose Genundewa blocks in roadfill along US 20 immediately east of the Old Telephone Road junction with US 20 at Bethany, New York (Fig. 14). Exit vehicles and proceed west uphill along US 20 to the Bethany Center Road overpass. The Genundewa Limestone is displayed in the protected area directly under the bridge.

This section illustrates the twofold internal division of the Genundewa Limestone, characteristic of this area, with the lower and upper Genundewa styliolinid units (Fig.14, units c and e) separated by a complex, nodular, internal zone of conodont-rich lag debris corresponding to the North Evans Limestone (Fig.14, unit d). Of particular note is the presence of *Trypanites* (borings) into attached Penn Yan concretions (Fig.14a); this indicates the presence of a sub-Genundewa discontinuity (Fig.14b) in this area that is distinctly older than the intra-Genundewa North Evans contact (see text). Also important is the excellent development of cephalopod limestone facies within the lower Genundewa division (Fig.14c). We will see this facies to advantage in loose blocks in the US 20 road berm downhill past the Old Telephone Road exit where the vehicles are parked. This is one of the best examples of *cephalopodenkalk* facies to be seen in North America. Such facies is interpreted to represent deeper water dysoxic conditions where remains of pelagic (planktonic and nektonic) organisms accumulated in a sediment-starved setting (see text). The goniatite fauna includes *Koenenites styliophilus, Acanthoclymenia genundewa,* and *Tornoceras uniangulare compressum* (see Kirchgasser et al., 1994, for illustrations of Genesee Group goniatites). Pyritic replacements of *Acanthoclymenia* occur here at the contact with the overlying West River Formation.

Proceed east, downhill along US 20 to road fill berm past the Old Telephone Road pull off. Sample blocks exposed on the partly overgrown berm slope. Return to vehicles.

End of field trip.