MIDDLE – UPPER DEVONIAN DEPOSITIONAL AND BIOTIC EVENTS IN WESTERN NEW YORK

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INTRODUCTION

The Middle and Late Devonian succession in the Buffalo area includes numerous dark gray and black shale units recording dysoxic to near anoxic marine substrate conditions near the northern margin of the subsiding Appalachian foreland basin. Contrary to common perception, this basin was often not stagnant; evidence of current activity and episodic oxygenation events are characteristic of many units. In fact, lag deposits of detrital pyrite roofed by black shale, erosional runnels, and cross stratified deposits of tractional styliolinid grainstone present a counter intuitive image of episodic, moderate to high energy events within the basin. We will discuss current-generated features observed at field stops in the context of proposed models for their genesis, and we will also examine several key Late Devonian bioevents recorded in the Upper Devonian stratigraphic succession. In particular, two stops will showcase strata associated with key Late Devonian extinction events including the Frasnian-Famennian global crisis. Key discoveries made in the preparation of this field trip publication, not recorded in earlier literature, include: recognition of wave?-generated bedding and substrate channelization in styliolinid grainstone deposits of the Genundewa Limestone; discovery of a horizon in the lower Rhinestreet Shale with the chronozonally important goniatite cephalopod *Naplesites* and possibly dateable conodonts a few meters above a lag bed with Montagne Noire (MN) Zone 7 conodonts and a K-bentonite horizon presumably older than the Belpre Ash Bed of the southern Appalachian Basin (MN Zone 8); recognition of abundant phosphatic nodules in the Rhinestreet Shale cored by fish bones and scales; and discovery of a possible thin K-bentonite within the Pipe Creek Shale (= Upper Kellwasser Bed marking a global extinction-ecological disturbance event) allowing for potential absolute dating of that event.

This field trip differs from earlier ones in that it does not focus on any particular stratigraphic unit or problem. Rather we will provide somewhat of an ascending "Cook's tour" of units proceeding southwestward across Erie County from the lower medial Hamilton Group (STOP 1) to the Frasnian-Famennian mass extinction (STOP 7). This trip is, however, complimentary to our Sunday field trip (this volume) which focuses in more detail on the origin of the distinctive North Evans Limestone/Genundewa Limestone that we will see at STOP 2. For the benefit of participants, several of the newly-generated schematics are presented both in the Saturday and Sunday fieldtrip papers. In the tradition of NYSGA serving as a teaching forum, this fieldtrip is presented as "work in progress" and is designed to review controversies and ongoing questions. Although material covered is somewhat of an eclectic mix, this should lead to a broader array of issues to be addressed. Moreover, we have discovered several new features in several Late Devonian (Frasnian-Famennian) sections during field trip preparation that demand further investigation. These discoveries, discussed below, include the recognition of small-scale hummocky cross-stratification and substrate channelization in the Genundewa Limestone, the finding of a new K-bentonite bed in the Pipe Creek Shale, the discovery of a geochronologically important occurrence of goniatites in the lower part of the Rhinestreet Formation, and the discovery of abundant phosphatic nodules containing fish bones and spines, also in the lower part of the Rhinestreet Formation. Thematic aspects of this trip will be: firstly, to examine evidence of current activity and bottom erosion in several basinal shale-dominated units intuitively viewed as "deep water" and "basinal," secondly, to look at distinctive facies and event horizons at different levels, and thirdly, to look at levels linked to key Late Devonian bioevents.

GEOLOGIC SETTING

During the late Middle Devonian western New York was located in the southern hemisphere tropics or subtropics and covered by an epicontinental sea (Scotese, 1990). Strata 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; Fig. 1). The most pronounced thrust loading event (tectophase three) coincided with the onset of the deposition of the Genesee Group; 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; Baird et al., 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 with Leicester Pyrite at its base, Penn Yan Formation, and condensed North Evans/Genundewa deposits, are observed to successively onlap a major regional disconformity (Taghanic Unconformity) in a westward direction (Fig. 2). This disconformity, separating fossiliferous neritic facies of the late Middle Devonian (Late Givetian) Windom Member of the Hamilton Group from overlying dysoxic, pelagic limestone and lag debris (North Evans/Genundewa deposits), will be seen at STOP 2. In west-central New York localities, the gradational transgressive change from Tully carbonate facies into black shale of the Geneseo Formation coincides with the beginning of the upper Givetian substage of the late Middle Devonian (Huddle, 1981; Kirchgasser et al. 1989; R.T. Becker, personal comm., 2006). Proceeding westward along the Taghanic disconformity, the ages 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 Limestone conodont – bone lag below the Genundewa Limestone, oversteps the Taghanic disconformity in Erie County, thus merging the two discontinuities into a composite unconformity (Fig. 2). Hence, at STOP 2, the Late Devonian (early Lower Frasnian) North Evans Limestone rests directly on late Middle Devonian (middle Givetian, *ansatus* Zone) shales of the Windom Member (Moscow Formation; Hamilton Group) with several conodont chronozones missing or whose representatives were reworked and transported. The effective chronostratigraphic (taphonomic) age of the North Evans is early Frasnian upper MN Zone 2 (Figs. 2-3).

Acadian orogenic uplift in New England and the central Atlantic region was associated with progradational developmemt of the Catskill Delta Complex which filled the foreland basin from east to west (Woodrow and Sevon, 1985; see Kirchgasser et al., 1997). Catskill Delta

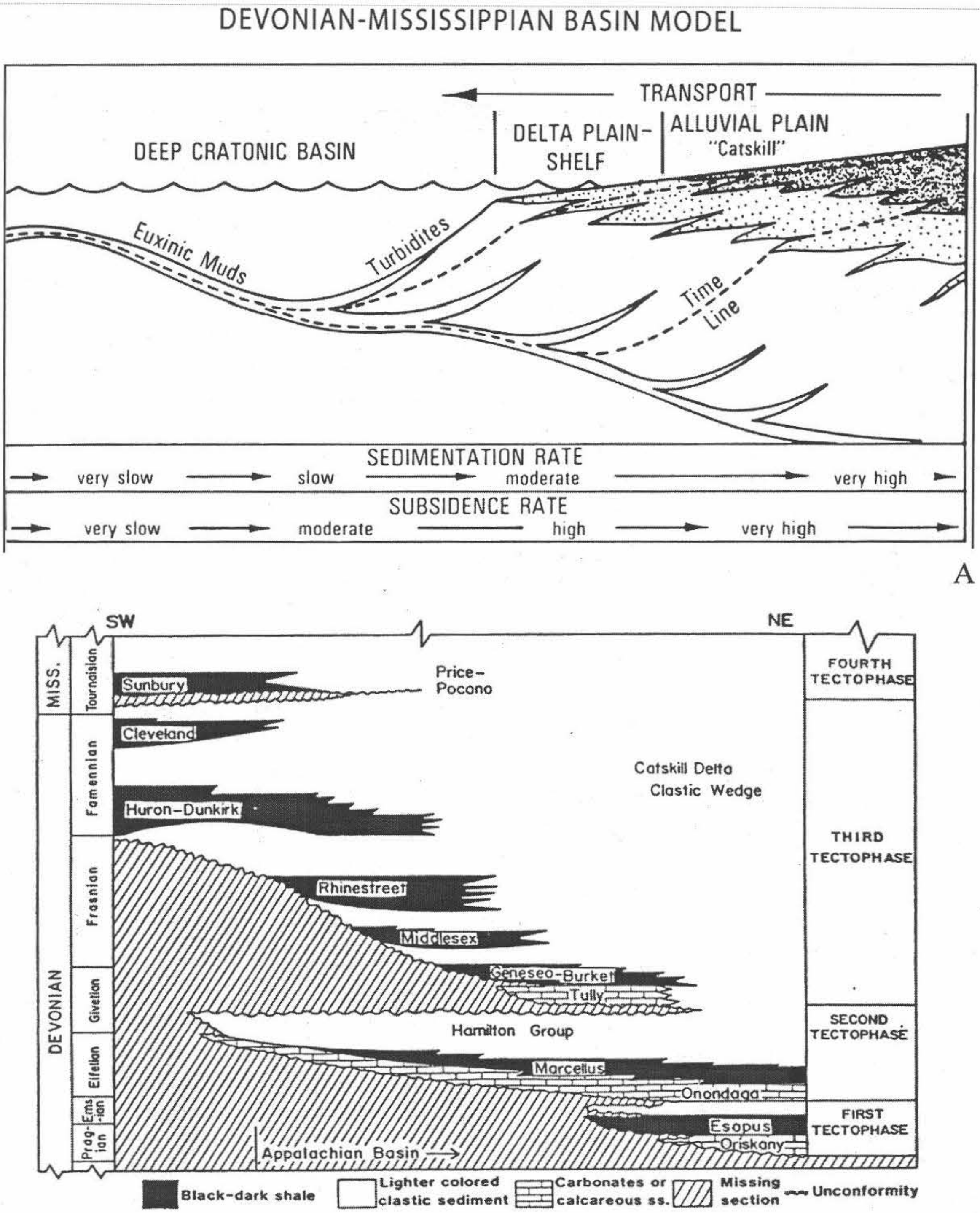

Figure 1. **A.** Idealized depositional model of the Catskill Delta complex (from Broadhead et al., 1982). **B.** Composite stratigraphic section from east-central New York to north-central Ohio in the northern Appalachian Basin showing distribution in time of pre-tectophase unconformities and unconformity-bounded flexural sequences of black shales and coarser clastic sediments attributed to four Acadian tectophases. Note progressive southwestward (cratonward) basin migration of successive black shale strata (from Ettensohn, 1994).

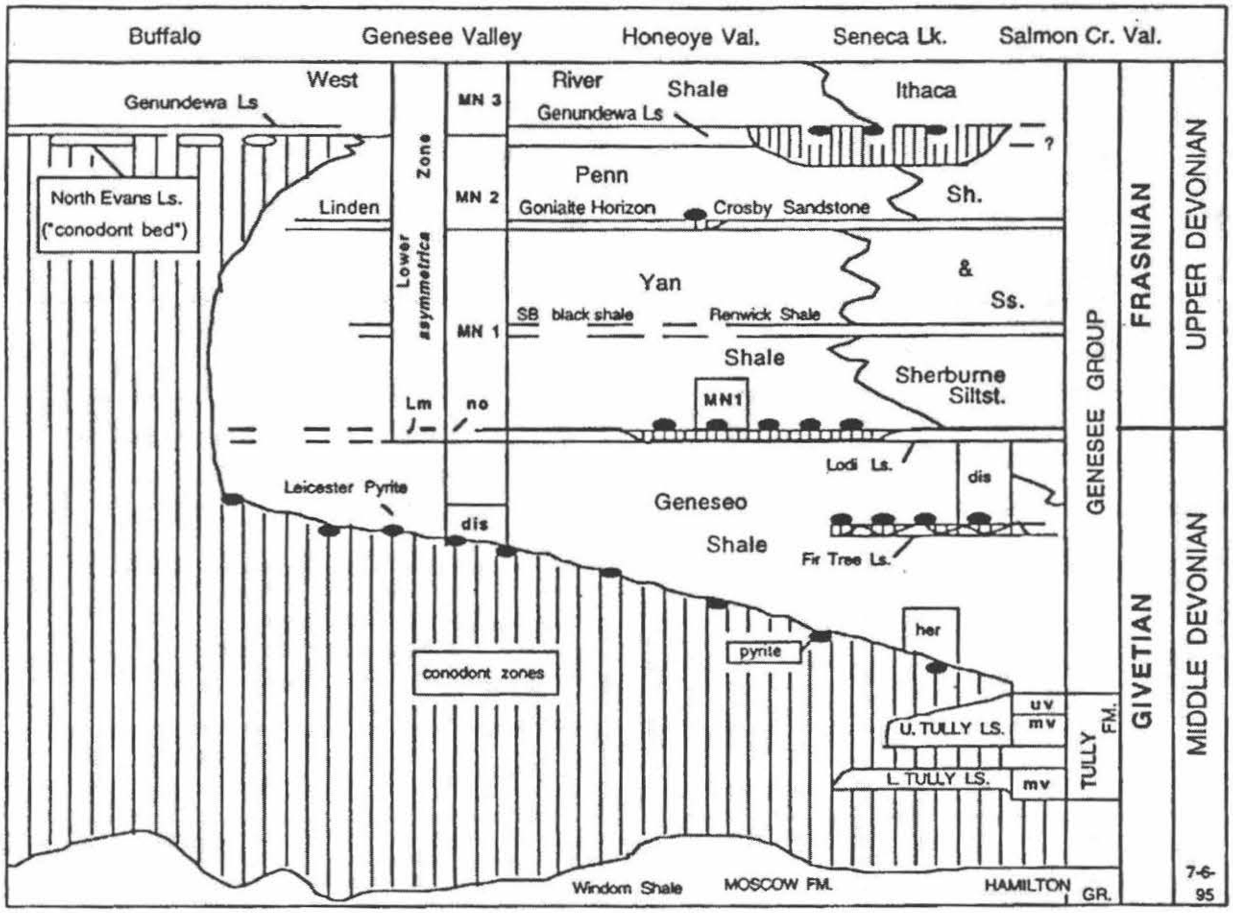

Figure 2. Generalized chronostratigraphic cross section of lower Genesee Group and subjacent Moscow Formation (Hamilton Group, Windom Shale Member). Large hiatus below Genesee Group marks position of compound Taghanic Unconformity, Genesee onlap succession and sub-Genundewa unconformity. The pre-Tully 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 of the gap of the compound unconformity is greatest. Lenses of North Evans debris with *ansatus* Zone (Middle *varcus*) to upper MN Zone 2 conodonts and Frasnian goniatites (*Koenenites*) are traceable beneath the sub-upper Genundewa disconformity as far east as the Genesee Valley. (From Kirchgasser, Brett and Baird, 1997, fig. 7). See Fig. 3 for names of conodont zones.

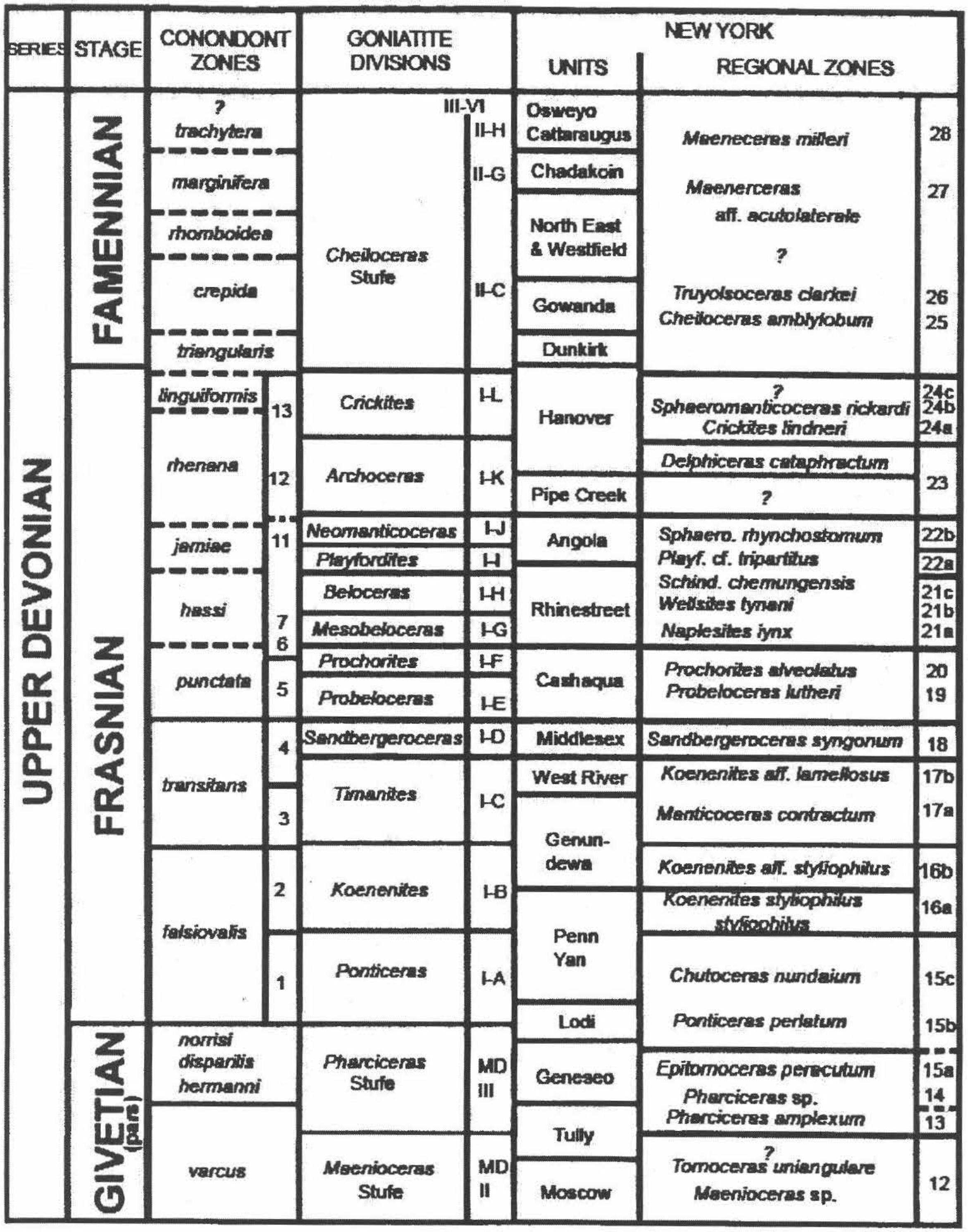

Figure 3. Late Devonian (Givetian, Frasnian, and Famennian) stratigraphic succession in New York State showing alignment to international conodont zones (Standard and Montagne Noire [1-13]) and goniatite cephalopod divisions and New York regional goniatite zones (12 to 28). MN Zone assignments follow Kirchgasser and Klapper (1992), Kirchgasser (1994), and Klapper et al. (1995). Modified from House and Kirchgasser (1993 and in press).

progradation began in earnest during deposition of the Middle Devonian Hamilton Group following the 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 which are typically much coarser (Fig. 2).

Generally, the units seen on this field trip represent very fine grained detrital facies of the Catskill Delta representing deposition in deeper water slope and basin settings both at and beyond the delta margin (Fig. 2). Units such as the Rhinestreet Formation of the West Falls Group (Late Devonian, Frasnian) are typically expressed along Lake Erie as organic-rich, fissile to massive, black shale facies recording near-anoxia during phases of transgressive highstand (Rhoads and Morse, 1971; Murphy et al., 2000). However, thinner intervals of gray-green, typically bioturbated shale occur within the Rhinestreet (see STOPS 3-5). Shale of this type thickens greatly eastward toward the depocenter and sediment source. Black shale units, including the Rhinestreet, typically split into eastwardly splaying black shale tongues (Fig. 1). At STOPS 3 and 5 we will see that some of the gray-green shale shows little evidence of bioturbation and may be turbiditic or hemipelagic in origin. The black shale facies is often laminated, but actually, typically displays small flattened burrows, indicating the bottom setting was not exclusively anoxic.

CURRENT ACTIVITY ALONG DEVONIAN SLOPE AND BASIN SUBSTRATES: GENESIS OF BASINAL DISCONTINUITY SURFACES, CHANNELS, AND SMALL-SCALE HUMMOCKY CROSS-STRATIFICATION

Baird and Brett (1986) undertook a regional study of the Leicester Pyrite, a bone/conodont-rich detrital pyrite deposit associated with the Taghanic Unconformity and onlap surface (basal Geneseo black shale contact) from Ontario County westward into eastern Erie County (Fig. 2). Very coarse detrital pyrite was found to occur in laterally disconnected lenses up to 30 cm in thickness along the contact and also slightly above the contact within the black shale. We interpreted the Leicester to be a coarse lag deposit comprised of pyrite derived from the underlying Windom Member and moved by currents along the Taghanic Unconformity surface within erosional channels cut into the underlying shale (Baird and Brett, 1986). The fact that some lenses occur above the contact within the Geneseo Shale demonstrated contemporaneous deposition of the detrital pyrite with the onlapping black muds of the Geneseo; hence, the pyrite and other insolubles were swept downslope over the leading edge of the onlapping organic-rich sediment within the setting of black mud accumulation. This model is further supported by the chronostratigraphic diachroneity of the basal Geneseo Shale (Fig. 2). The development of a channeled regional slope is suggested by the occurrence of the Leicester Pyrite in discrete lenses which could be channel fills. Unfortunately, owing to the direction of our field excursion, we will not encounter true Leicester in our sections. However, at STOP 1, we will see discrete erosional runnels, probable furrows *sensu* Flood (1983), associated with a discontinuity in the lower part of the Levanna Member, Skaneateles Formation within the Middle Devonian Hamilton Group (Baird and Brett, 1991; Fig. 4). The long cutbank section showing this discontinuity shows a series of small shale-filled channels which are crossed transversely (Fig. 5). Some of the larger channels contain lags of small brachiopods and fish bones in their axes.

The channels at STOP 1 are probably smaller versions of those associated with deposition of the Leicester. More recently Schieber (1994; 1998) described numerous occurrences of arcuate erosion surfaces within black basinal facies of the Late Devonian Chattanooga and Ohio shales; these undulating, concave scours reveal truncation of beds both between outcrops and within outcrops. Such contacts may be channeled in a manner similar to the Levanna examples at STOP 1.

Baird and Brett (1986, 1991) discussed a variety of mechanisms to produce coarse tractional lags in black shale settings in the context of a basinal, deeper-water setting interpreted for such facies. Processes including: deep-storm wave impingement, bottom current processes, and internal waves were examined 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 by internal waves generated along the pycnocline 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 Unconformity 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). 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 along a 100 km lateral distance across western New York. 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. Subsequent slope drowning with consequent overspread of dysoxic water below the pycnocline was believed to explain the dissolution and 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 Geneseo time, the basal Geneseo lag would always be made up of insoluble material (Baird and Brett, 1986).

It is significant that the Leicester example is not isolated; coarse insoluble lags associated with Devonian black shale-roofed unconformities have been examined elsewhere (see summary in Baird and Brett, 1991; Schieber, 1994, 1998; Brett et al., 2003). Moreover, in the Rhinestreet Formation (STOPS 3-5) and in the upper part of the Hanover Formation (STOP 7), we will observe numerous gray-black shale alternations where thin black layers, some only millimeters-thick, rest sharply on gray shale units. Some of these contacts display thin lags of reworked wire-like, pyritic burrows, flattened goniatites, some with pyritized sutures, and geopetally pyrite-filled, spherical cysts of the algal taxon *Tasmanites* (Schieber and Baird, 2001). Lags flooring these thin black layers are much thinner and finer than those associated with the major contacts.

Juergen Schieber, by contrast, argues for a shallower water origin of these discontinuities and associated black shale facies based on his work on the Ohio, Chattanooga, and New Albany shales (Schieber, 1994, 1998). Coarse tractional siltstones, sandstones, and shell beds within the very condensed black, Chattanooga Shale are interpreted by him as being the result of storm wave impingement. Calculations of orbital wave velocities accounting for coarse sand and

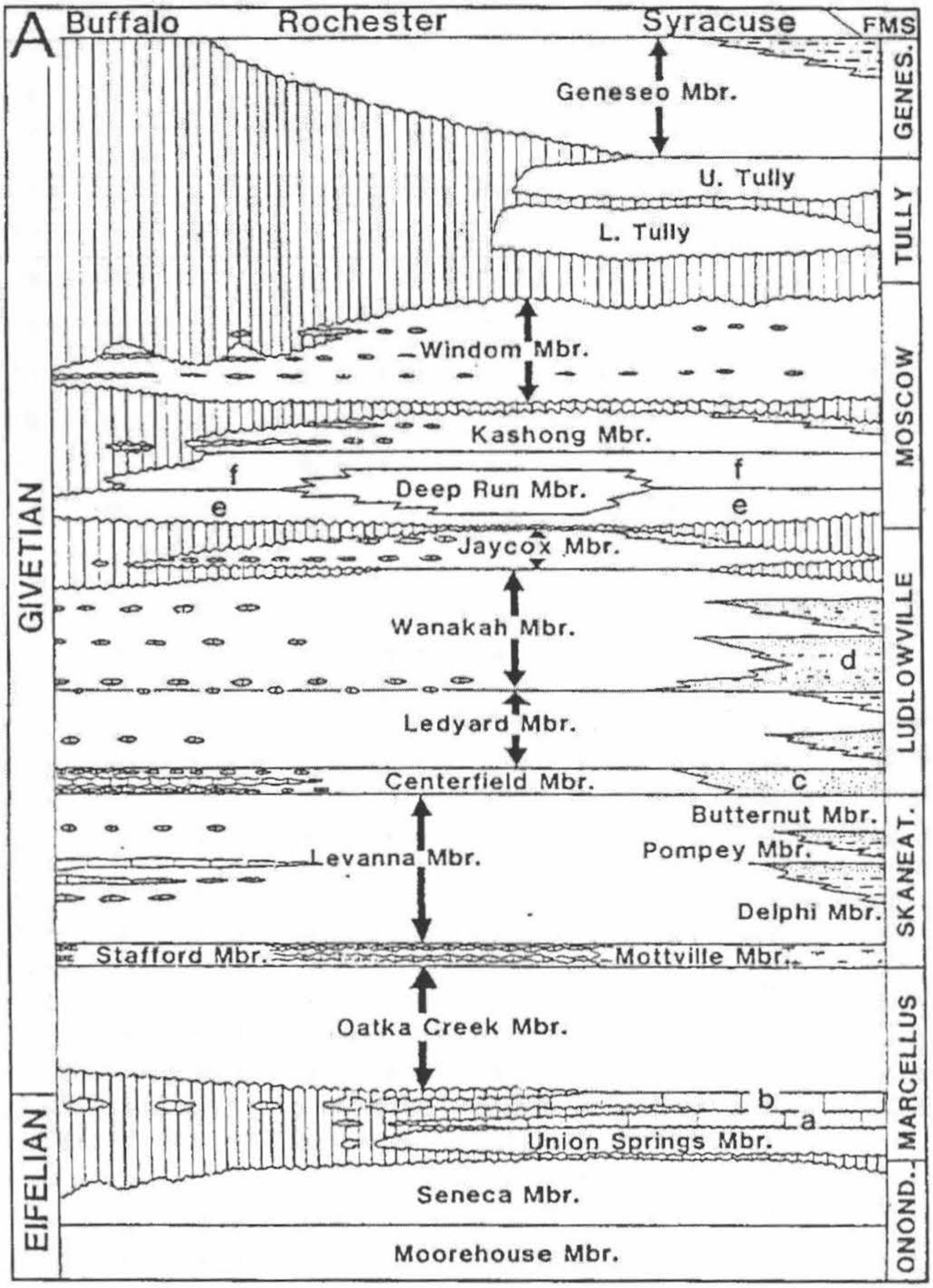

Figure 4. Time-rock diagram of upper Eifelian to upper Givetian succession in central and western New York showing the position and distribution of Ledyard Shale Member of the Ludlowville Formation (Hamilton Group), the unit to be seen at STOP 1. (From Brett and Baird, 1996 after Brett and Baird, 1994; also Kirchgasser, Brett and Baird, 1997, fig. 5).

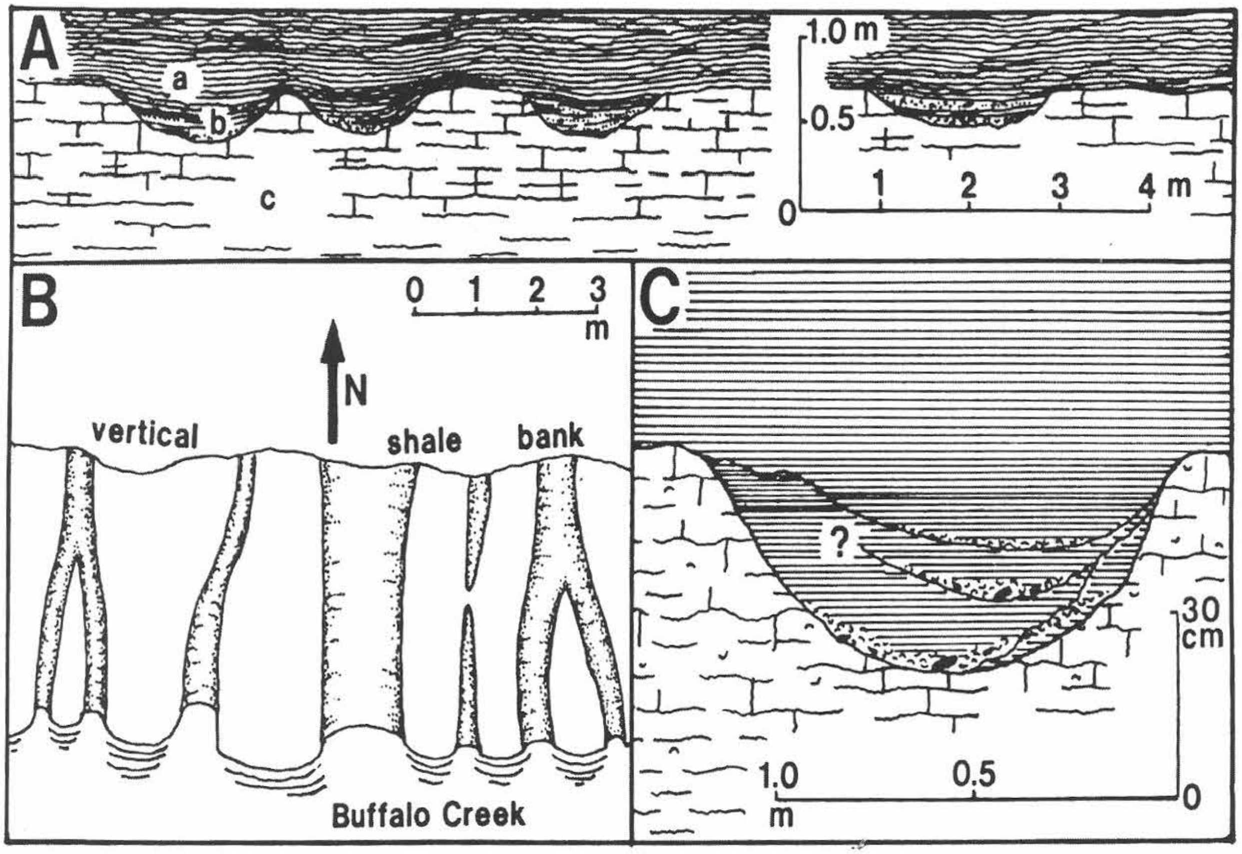

Figure 5. Submarine discontinuity within Levanna Shale Member on Buffalo Creek opposite Charles Burchfield Museum and Nature Center, upstream from (east of) Union Road overpass (see STOP 1). A, Along-bank profile of a series of erosional runnels (troughs) cut into calcareous shale that are filled with brownish black shale of upper unit; B, Vertical ("map") view of channels on exposed creek bed bordering shale bank. Note southward bifurcation of some channels suggestive of southward current flow; C, Complex history of episodic filling scouring and filling of mud within channels. Sharp scoured contacts with associated lag debris of fish bones and shells grade laterally to extinction (continuity) over very short distances. Lettered units include: a, black, laminated shale with flattened rhynchonellids, *Styliolina*, and palynomorphs; b, brown-black shale filling in troughs with associated scoured contacts and mixed brachiopod, trilobite, and fish bone lag debris; c, calcareous gray to dark gray blocky to chippy mudstone with *Ambocoelia, Devonochonetes,* and *Eldredgops* (from Baird and Brett, 1991; Baird et al., 1999).

detrital pyrite transport, as well as the scouring of consolidated shale, yielded velocities in excess of 150 cm/sec. suggesting water paleodepths of as little as 10 meters (Schieber, 1994, 1998). These contrasting models revive the long-standing "black shale paleodepth controversy" that has long existed. Very coarse, "grit- grade" pararipples and sheet sands occur within black shale facies of the Dowelltown Member of the Chattanooga Shale west of Nashville, Tennessee [G.C. Baird and A.J. Bartholomew (SUNY-New Paltz), unpublished observations]. Not only does cross laminated, grit-grade, quartz and phosphatic sand rest on the sub-Chattanooga disconformity, but it also occurs at numerous overlying levels within the Dowelltown. Clearly, Schieber's storm model appears to have some credibility in explaining black shale features on the Nashville Dome. The coarse-grained Dowelltown beds, as well as the Leicester and its analogs, pose a key question; how does one reconcile "basinal," widely-distributed, and near-anoxic, organic-rich shale with evidence for high energy current activity? Are these units truly shallow with a pycnocline maintained just below the sea surface, to be disrupted intermittently by storms? Does a shallow-to-deep spectrum of Devonian black shale types exist within the Appalachian Basin and beyond? If shallow Devonian black shales exist, are these maintained by enormous surface productivity or by purely physical mechanisms? Until a good actualistic (modern) example of Leicester-type deposits is found forming, they will remain an intriguing enigma, but also a key insight in our overall understanding of sedimentary processes in the rock record.

The model of regional bed onlap and deeper-water pycnoclinal erosion can also be applied to the younger North Evans bone/conodont lag bed flooring the Genundewa Limestone (see STOP 2; Fig. 6). As will be discussed more fully on the Sunday (B 3) field trip (this volume), the Genundewa Formation of the Genesee Group is a condensed pelagic limestone unit almost entirely composed of the problematic conical microfossil *Styliolina fissurella* [Order Dacryoconarida Fisher, 1962; see Lindemann (2002) for summary of dacryoconarid classification]. It appears to mark a transgression from a eustatic (or tectonically induced) lowstand event recorded by a regional unconformity marking the top of the Penn Yan Shale and an associated coarse lag unit known as the North Evans Limestone bone/conodont bed ("Conodont Bed" of Hinde, 1879; Fig. 2). Recent work (see fieldtrip B3, this volume) shows that dysoxic Genundewa styliolinid carbonate grainstone facies appear to onlap the unconformity surface to the northwest (inferred foreland basin margin) to the point of near bed-extinction in eastern Erie County. The North Evans Limestone, similar to the Leicester Pyrite, is very coarse; it contains reworked fish teeth, bones, spines, scales, abundant pelmatozoan debris, pyritized mollusks, including early whorls of goniatites, and a rich and famous concentration of conodonts, an amalgamation of late Givetian and early Frasnian elements spanning several conodont zones (Baird and Brett, 1982; Brett and Baird, 1990; Bryant, 1921; Huddle, 1974, 1981; Kirchgasser, 1994; Hussakoff and Bryant, 1918; Over et al., 1999). 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 ramp prior to its subsequent dissolution at greater depth (Brett and Baird, 1982; Baird and Brett, 1986). At STOP 2 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. 6). In this area the North Evans lag debris was exposed to more severe dysoxic conditions than elsewhere; it is distinctly more pyrite-rich and is greatly reduced in volume.

Above the North Evans Limestone at STOP 2 is a 25 cm-thick black shale unit that is rich in flattened *Styliolina* shells which, in turn, is overlain by the Genundewa Limestone, a 30 cm-thick layer of dark gray, styliolinid grainstone-packstone carbonate that is regionally widespread (Figs. 1, 6). *Styliolina fissurella* is a problematic 1-2 mm-long calcareous conical shell of uncertain affinities. It was originally described erroneously from flattened material, hence the specific name "*fissurella*" (see Hall, 1843, 1879). Subsequent workers placed these organisms in a the Nashville Dome. The coarse-grained Dowelltown beds, as well as the Leicester and its analogs, pose a key question; how does one reconcile "basinal," widely-distributed, and near-anoxic, organic-rich shale with evidence for high energy current activity? Are these units truly shallow with a pycnocline maintained just below the sea surface, to be disrupted intermittently by storms? Does a shallow-to-deep spectrum of Devonian black shale types exist within the Appalachian Basin and beyond? If shallow Devonian black shales exist, are these maintained by enormous surface productivity or by purely physical mechanisms? Until a good actualistic (modern) example of Leicester-type deposits is found forming, they will remain an intriguing enigma, but also a key insight in our overall understanding of sedimentary processes in the rock record.

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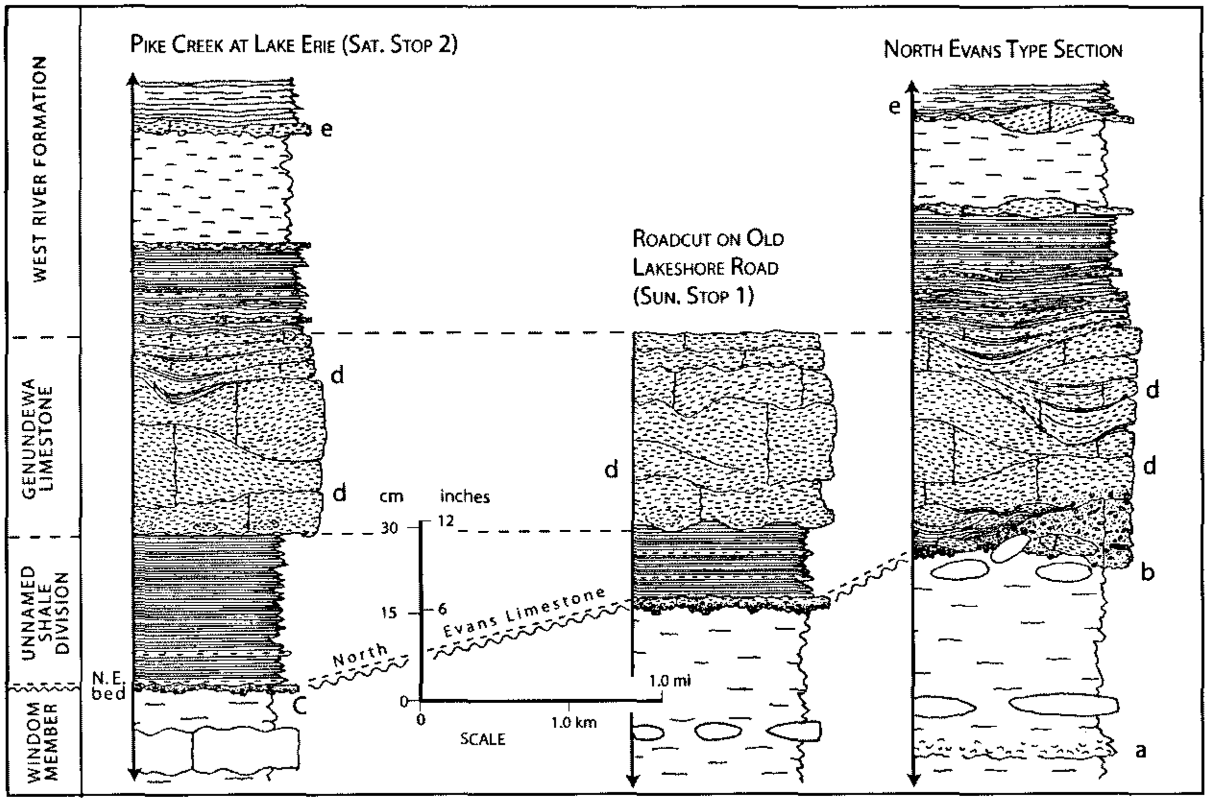

Figure 6. Genundewa Limestone and associated units in the vicinity of Lake Erie. Note prominent westward thinning of the North Evans lag deposit coupled with westward appearance of an unnamed black shale unit that seperates the North Evans from the overlying Genundewa (see discussion in text). Also visible is distinctive pinching and swelling of beds with associated localized channeling within the Genundewa. Lettered units include: a, Amsdell Bed of Windom Member yielding abundant *Emanuella praeumbona*; b, thick, pelmatozoan-rich subfacies of the North Evans Limestone; c, thin, pyrite-rich subfacies of the North Evans Limestone; d, Genundewa styliolinid grainstone-packstone carbonate facies; e, thin, lenticular, styliolinid limestone bed in the West River Formation yielding glauconite and abundant conodonts; this is sample-bed USGS 8122-SD Fall Brook, Geneseo (Livingston County) of Huddle (1981).

Acanthoclymenia, and *Tornoceras* , crinoid ossicles, and wood debris, can be found (see Kirchgasser et al., 1994, fig. 7, for sketches of the goniatites). The biota is of low diversity and suggests a dysoxic stressed environment, particularly, when compared to the rich, high diversity benthic fauna of the Tichenor Limestone, a carbonate unit of comparable thickness 6 meters below the Genundewa at STOP 2. 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 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; House and Kirchgasser, 1993). Basins between these swells received contemporaneous accumulation of thick shale units where turbiditic facies 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 (Fig. 6). However, it is locally packed with goniatite phragmocones in a manner typical of many cephalopodenkalk units (see Sunday Field Trip B3: STOP 4, this volume).

The Genundewa in Erie County is usually massive, but when weathered, the limestone typically splits apart into nodular and flaggy beds (Sass, 1951; Baird and Brett, 1982; Brett and Baird, 1982). Nodules occur as laterally linked to separate zones of sparry styliolinid limestone surrounded by muddy styliolinid partings. Bedding in the Genundewa is usually laminar with some evidence of bioturbation. Preparation for the present field trip led to discovery of cross stratification within the Genundewa along the Lake Erie shore bluffs southwest of Pike Creek (STOP 2) and nearby on Eighteenmile Creek (Fig. 6). 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 (Fig. 6). 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.

LATE DEVONIAN BASINAL FACIES AND EVENT HORIZONS

A sequence of alternating black and sparsely fossiliferous gray shale units (West River Formation-through-Dunkirk Formation) characterize the Late Devonian Frasnian and basal Famennian succession in southern Erie County. Inferred paleoenvironments range from nearly anoxic for portions of black shale units to more broadly dysoxic for the gray facies. No unit in this succession yields a significant benthos, though, as we will see, some strata yield a variety of pelagic taxa.

On the Lake Erie shore southwest of Pike Creek (STOP 3), Sturgeon Point (STOP 4), and on Eighteenmile Creek southeast of North Evans (STOP 5), we will examine the lower part of the black Rhinestreet Formation, a major division of the West Falls Group (Fig. 7). Within the larger black shale interval is a 2.2-2.4 m-thick interval of predominantly gray shale with thin "pinstripe" black shale bands at several levels (Fig. 7). This is well exposed at the lakeshore sections (STOPS 3 and 4) where a basal turbiditic? siltstone bed marks the base of the interval. Although some bioturbation can be seen in the gray shale, much of it is fine grained, conchoidal "satin shale," suggestive of turbiditic or hemipelagic origin. Hence the gray shale complex appears to be the distal "toe" of prodelta sediments within the basin. At STOPS 3 and 5 a 1.0 cm-thick K-bentonite can be seen about one meter below the gray shale unit (Fig. 7). The pyroclastic character of this bed is revealed by an abundance of mica-rich clay which is suffused with diagenetic pyrite. This K-bentonite was earlier reported by Levin and Kirchgasser (1994) to be the Belpre Ash of Tennessee, but it now appears to be one conodont chronozone older (see STOP 3 discussion).

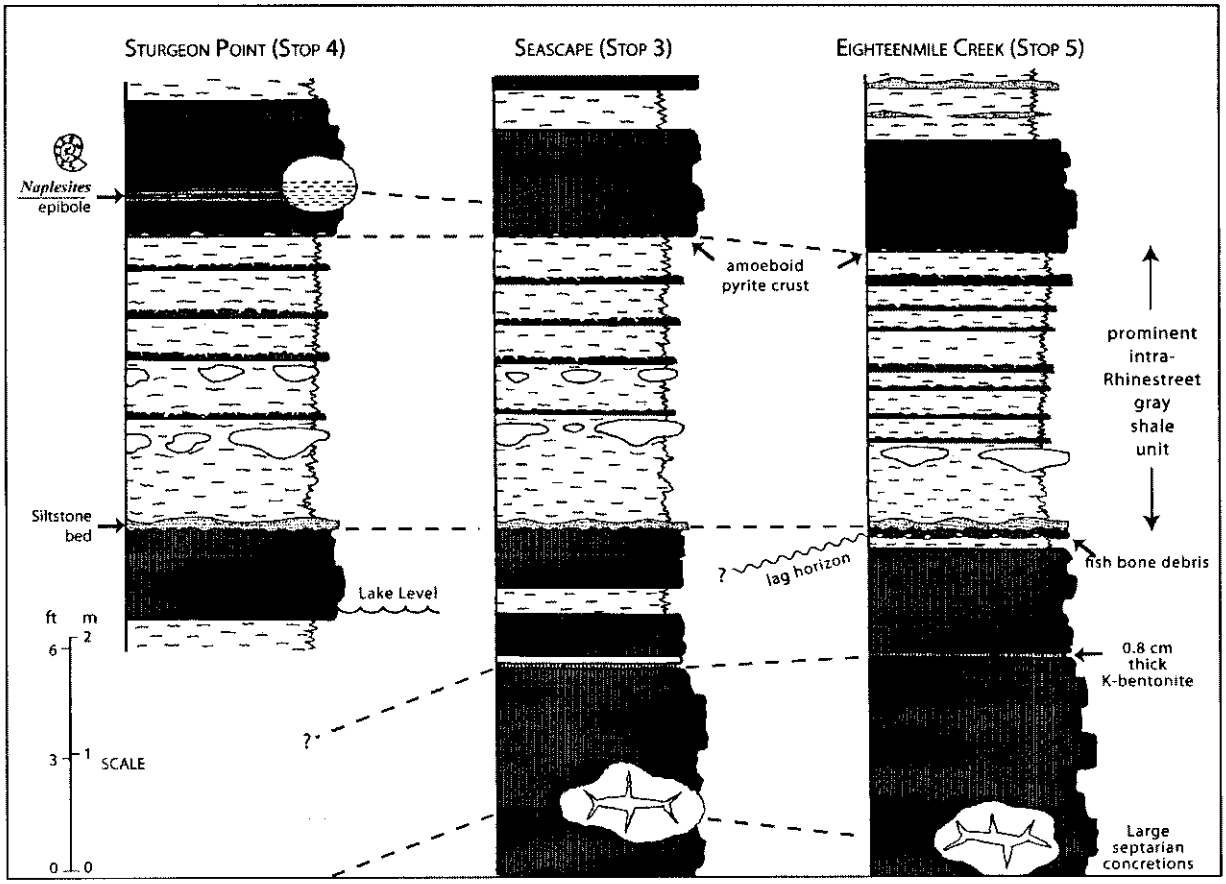

Figure 7. Unnamed gray shale division within the lower part of the Rhinestreet Formation in the vicinity of Lake Erie in southern Erie County. Note the numerous gray-green shale alternations within the gray shale division, the K-bentonite bed below it, and the *Naplesites* goniatite epibole above it (see text).

Some 40 cm above the gray shale interval exposed northeast of Sturgeon Point (STOP 5) is a 4 – 8 cm-thick interval of *Styliolina*–rich black shale that yields the zonally significant goniatite *Naplesites*, previously known in New York from a few specimens (presumably from the Rhinestreet Shale) that were reported by Clarke (1898) from around Naples in Ontario County (see STOP 4 discussion). This anomalous fossil concentration (*epibole*) was fortuitously discovered this past June when we completed a survey of this stop for the field trip. The discovery of conodonts in *Styliolina* concentrations associated with the goniatites, offers an opportunity to link conodont and ammonoid chronostratigraphic information. Moreover, given the possibility that the underlying K-bentonite can be radiometrically dated, a chronostratigraphic key point can be "hammered in" at this section. The goniatites are notable for their poor, ghost-like preservation in the black shale, suggesting that the aragonite of the phragmocone may have dissolved before significant mud compaction had taken place, but that the organic periostracum survived after compaction, leading to the flattened, composite impressions of these fossils; the edges of some of the septa (suture lines) are replaced by pyrite.

The goniatite clusters include a variety of ontogenetic stages from juveniles to adults with shell diameters exceeding 100 cm.

Southwest of the Sturgeon Point marina and car park is a low, resistant bench of Rhinestreet black shale that probably overlies most of the observed bluff section northeast of the point owing to dip effects. At the top of the bench and above a band of massive septarial concretions are two closely-spaced zones of small, 0.3 – 3.5 cm- diameter phosphatic nodules which occur interspersed among larger limestone concretions. Close examination of the phosphatic nodules shows that they selectively grew around fish bones, spines, and scales. The high proportion of fish- nucleated nodules in this location suggests a time of significant water column productivity and/or sediment condensation. This horizon may be one of many similar beds yet to be recognized in the Devonian basinal succession.

The closing of the Late Devonian Frasnian stage was marked by two major episodes of ecological disruption and faunal extinction. The second of these, marking the Frasnian-Famennian boundary and associated mass extinction, was the greater crisis globally. This extinction, in part, probably explains the lower diversity and more generalized ecological character of Famennian neritic faunas seen higher in the Devonian succession in Chautauqua and Cattaraugus counties, south of the field trip area. In Europe, North Africa, and elsewhere the two extinction events are marked by black shale or black limestone beds within slope and basin successions. These are known respectively as the "lower Kellwasser Bed" and "Upper Kellwasser Bed" in the literature (see Over, 2002; Racki, 2005; Schindler, 1993; Schindler and Königshof, 1997). Recently, both the lower and Upper Kellwasser equivalent beds have been found in western New York on the basis of lithology correlated to conodont zonation (Over, 1997, 2002; Day and Over, 2002; Over et al., 1997). The lower Kellwasser event is now linked to the Pipe Creek Formation, marking the base of the Java Group; we will see this unit on the south branch of Eighteenmile Creek (STOP 6; Figs. 8, 9). The Upper Kellwasser event correlates to a black shale bed in the upper part of the Hanover Shale Formation near the top of the Java Group (Over, 1997, 2002); we will see this bed on the south branch of Eighteenmile Creek (STOP 7; Fig. 10).

The Pipe Creek Formation at STOP 6 is a 1.5 meter-thick, very hard, black shale that abruptly overlies the softer, gray Angola Formation (Fig. 8). The laminated microfacies of the Pipe Creek contrasts dramatically with a subjacent zone of gray, pyritic Angola mudstone; this 15 cm-thick mudstone interval is thoroughly penetrated by networks of pyritic burrows which can be dramatically seen through x-ray imaging (Fig. 9). The Pipe Creek can be traced regionally southwestward into Chautauqua County where it thins to approximately 0.7 meters in its westernmost section (Tesmer, 1963). To the east, it thickens to about 6 or 7 meters near Warsaw, then becomes more depositionally complicated and interbedded with turbiditic silts and sands of the underlying Nunda Formation (Baird and Jacobi, 1999). The actual ecological reorganization-extinction event, best seen in neritic facies, is cryptic in Erie County; study of this faunal change will be the domain of work in equivalent silty-sandy facies in central New York. However, tentative discovery of a 1.2 cm-thick K-bentonite bed rich in pyroclastic micas in the Eighteenmile Creek section by the authors this past June offers the possibility that this interval can be dated radiometrically. Given that the Pipe Creek Formation is succeeded by gray, goniatite-bearing nodular shales of the basal Hanover Formation (STOP 6 description; Fig. 8), the combined radiometric date and the goniatite - conodont information will constitute a key point for the global Lower Kellwasser Event.

The Upper Kellwasser Bed is admirably exposed on the south branch of Eighteenmile Creek upstream from STOP 6 (Fig. 10). At this locality it occurs within the upper part of the Hanover Formation 2.4 meters below the base of the black lower Famennian Dunkirk Formation. Generally, the Hanover Formation is predominantly gray mudstone with a few rhythmic bundles of thin black shale units. Above the Pipe Creek and at several higher levels, this unit is spectacularly nodular with repeating bands of calcareous concretions and distinctive beds of irregular, closely crowded, beige nodules resembling calcrete (Fig. 8, unit g). Generally the Hanover yields only a low diversity fauna of ostracodes, small gastropods, bivalves, sparse goniatites, and small rugosans despite its light color, pervasive bioturbation, (including *Zoophycos*), and numerous carbonate layers. It appears to record relative sedimentary condensation under dysoxic conditions. However, compared to dysoxic – minimally oxic units in the Middle Devonian Hamilton Group (Levanna Member, Ledyard Member), the facies is markedly poorer in shelly benthos and richer in bands of small and irregular nodules. This suggests some dynamic geochemical-evolutionary changes across the Givetian and Frasnian that have yet to be identified or quantified.

The Upper Kellwasser Bed at STOP 7 is expressed as a fissile black shale unit with some silty laminations in the upper part (Fig. 10). This bed is herein designated the *Point Gratiot Bed* for an excellent exposure along Lake Erie at Point Gratiot at the southwest edge of Dunkirk, Chautauqua County. This layer, which is 15 cm-thick at Point Gratiot, is traceable eastward to the vicinity of Hornell and Canisteo in Steuben County where it is approximately 2 meters-thick (Over, 1997, 2002). At STOP 7 it displays both conformable, bioturbated lower and upper contacts and is 30 cm-thick (Fig. 10). At Point Gratiot and at Beaver Meadow Creek at Java Village the upper part of this layer has yielded articulated fish remains. At Beaver Meadow Creek, *Spathiocaris*, a probable cephalopod anaptychus, is common. It is important to note that the Point Gratiot Bed does not mark the base of the Dunkirk Formation of the Canadaway Group as was indicated by Baird and Lash (1990) and Baird and Brett (1991); the Point Gratiot Bed actually marks an apparent change to finer grained, more basinal facies *within* the upper part of the Hanover Formation [see revised schematic (Fig. 11) clarifying this relationship]. Between Point Gratiot and Java Village the interval between the Upper Kellwasser Bed and the overlying Dunkirk thickens from 15 cm to 7 meters with addition of numerous alternating black and gray-green shale beds (Fig. 11). The occurrence of reworked pyrite in the form of wire-like detrital burrow fragments at the bases of the black Dunkirk Shale and underlying upper Hanover black bands indicates that these contacts are of erosional character; some of the southwestward thinning of the upper Hanover is apparently due to collective overstep at such contacts (Baird and Lash, 1990).

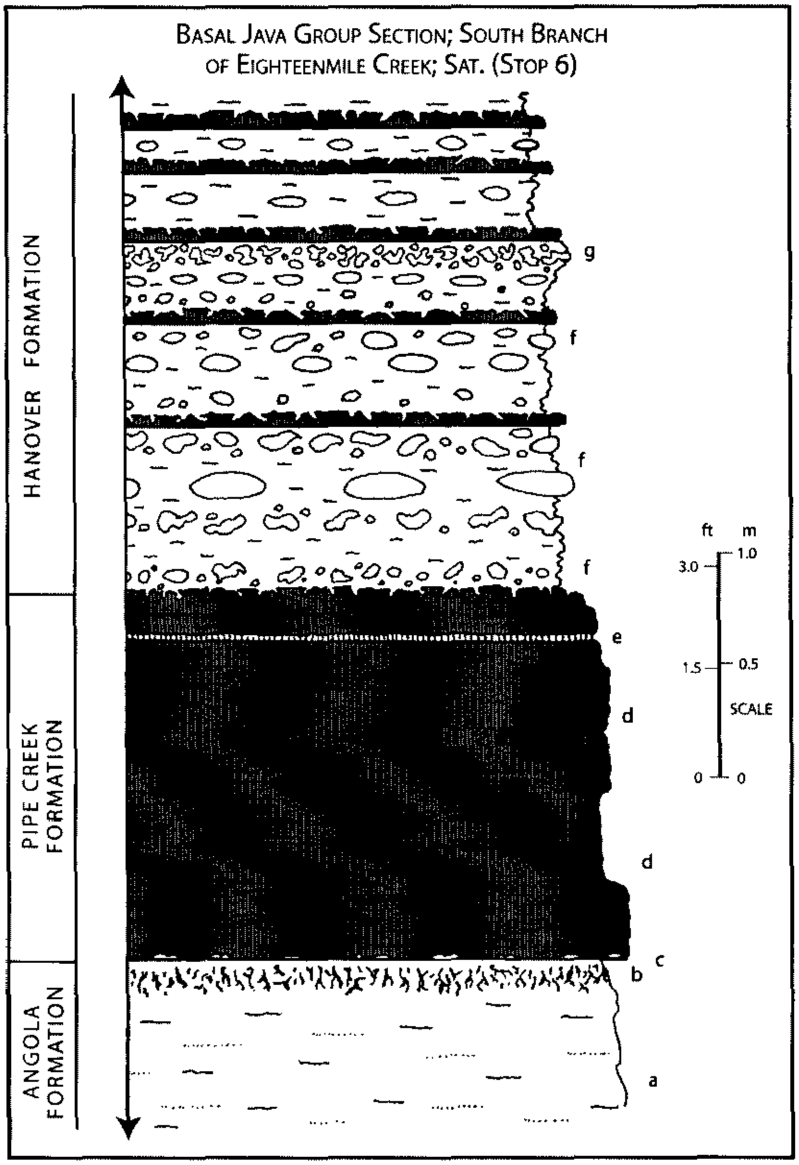

Figure 8. Pipe Creek Formation ("Lower Kellwasser Bed") and synjacent units capping major waterfall on the south branch of Eighteenmile Creek (STOP 6). Lettered units include: a, silty, gray mudstone deposits of topmost Angola Shale; b, 15 cm-thick diagenetic zone immediately beneath Pipe Creek Shale; rims of uncompacted burrows are selectively pyritized with center voids filled with sparry calcite; c, very sharp base of Pipe Creek with patchy, amoeboid, diagenetic pyrite, but no reworked pyrite (see also Figure 9); d, hard, black, well-jointed Pipe Creek Shale; e, 1.0 cm-thick gray clay bed yielding pyroclastic mica; f, basal, gray Hanover Shale characterized by profuse development of calcareous concretions and by the presence of thin black shale bands; g, conspicuous band of closely packed, irregular concretions that has a superficial resemblance to calcrete, but which appears to be a muddy version of basinal, condensed, nodular limestone facies described by others (see text).

The Upper *linguiformis* (MN Zone 13)/Lower *triangularis* chronozonal conodont boundary and inferred Frasnian-Famennian contact (Fig. 3) is crossed near or at the top of the Upper Kellwasser Bed based on work at Point Gratiot in Dunkirk, Irish Gulf, and at Beaver Meadow Creek in Java Village (see Over, 1997, 2002). Again, the major extinction event, observed globally at this level, is cryptic in the black shale facies except for the microfossil changes. However, one of us, Jeff Over, has described a bed of shelly taxa containing earliest Famennian brachiopods and bivalves in a thin, anomalous layer only one meter above the extinction horizon near Java Village (Day and Over, 2002). This "recovery layer" sheds important clues as to the nature of macrofossil changes in western New York following the mass extinction. Moreover, new fieldwork by Over in neritic deposits at this level further east near Hornell, and work by Baird in southern Chautauqua County, is shedding light on the more visceral effects of the extinction on shelly benthos and bioturbators in lower Famennian neritic deposits.

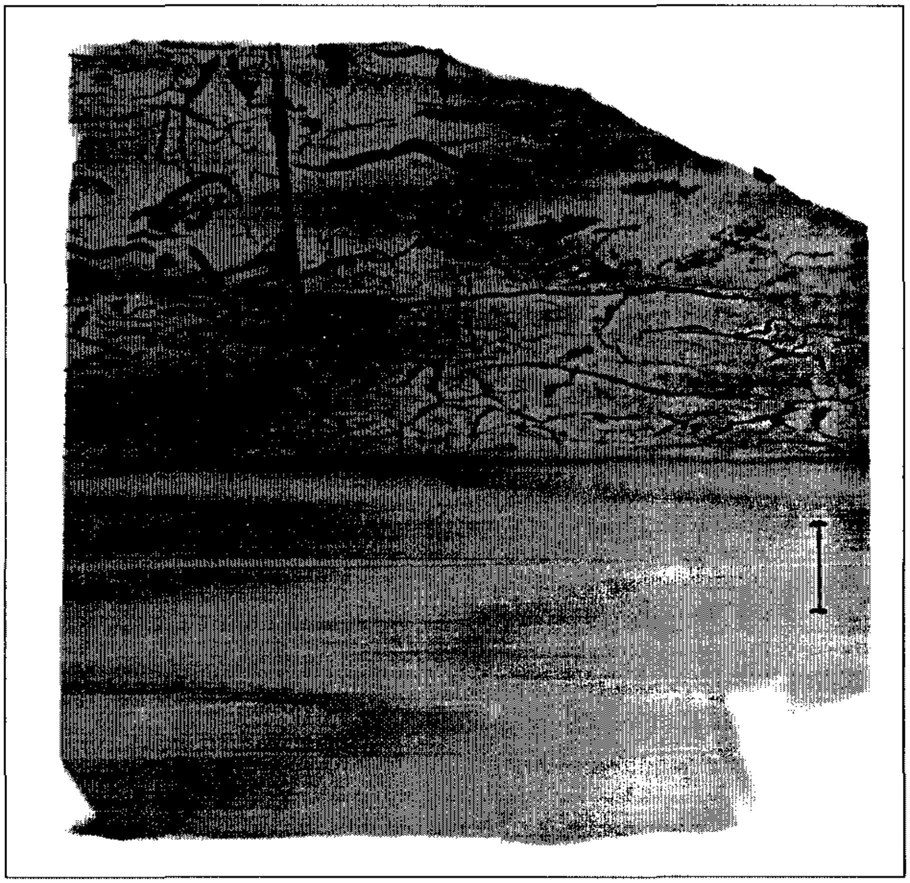

Figure 9. X-radiographic image of the contact between the Angola Shale and the overlying Pipe Creek Formation. Although this specimen is from the type Pipe Creek section near West Falls, Erie County, that contact is essentially identical to the one seen at STOP 6. Note the conspicuous vertical change from the bioturbated gray Angola into the laminated Pipe Creek lithology. Scale is 1.0 centimeter.

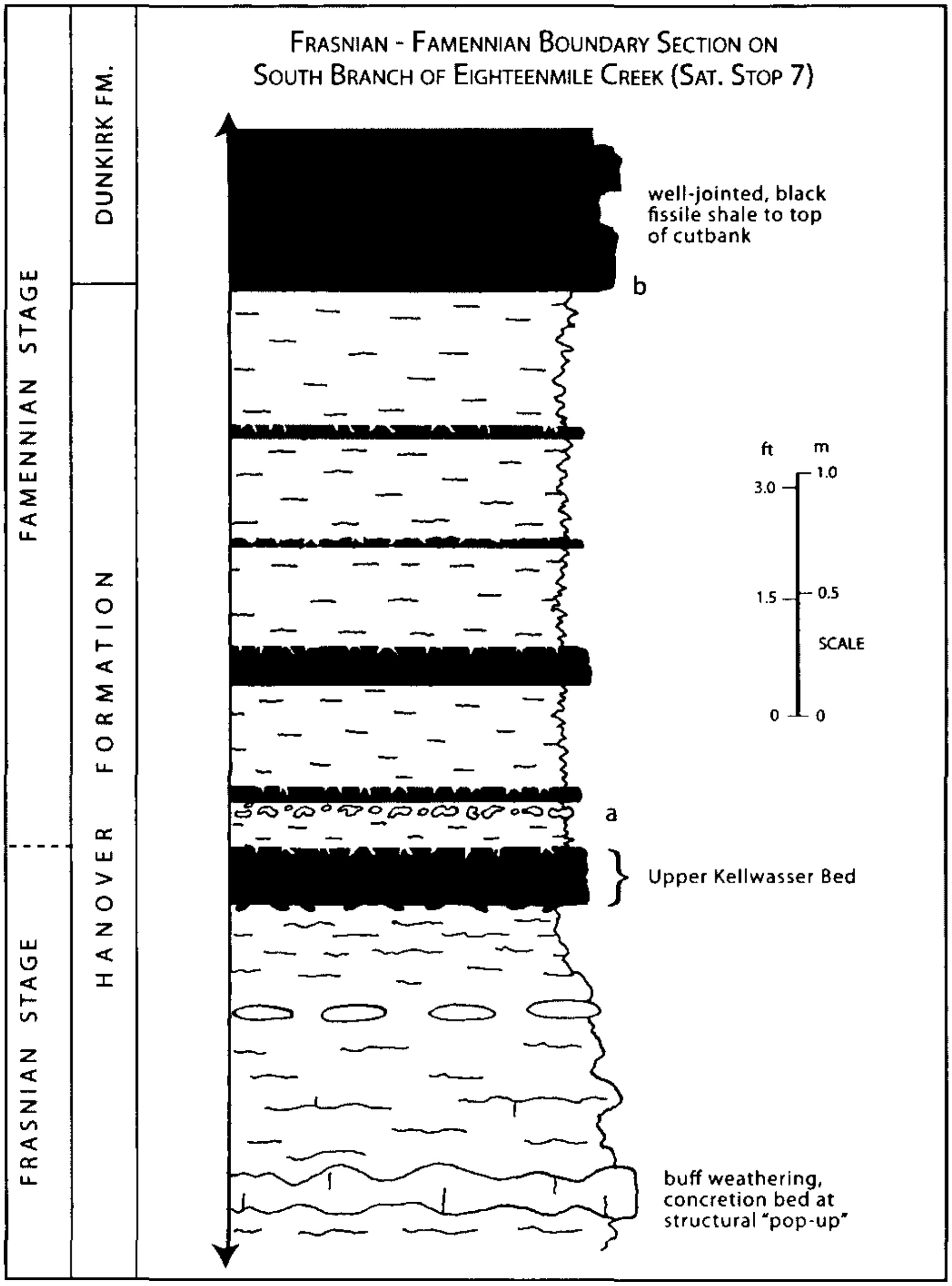

Figure 10. Frasnian-Famennian boundary horizon within the upper part of the Hanover Shale on the south branch of Eighteenmile Creek downstream from the New Oregon Road bridge near Clarksburg, Erie County. Note that the local Frasnian-Famennian boundary unit, corresponding to the global "Upper Kellwasser Bed" of chronostratigraphic literature, is herein designated the *Point Gratiot Bed* (see text). Lettered units include: a, zone of small concretions immediately below a thin, upper Hanover black shale bed; b, base of Dunkirk Shale, usually characterized in this area by a thin lag of reworked, wire-like, pyritic burrows (Baird and Lash, 1990; Baird and Brett, 1991).

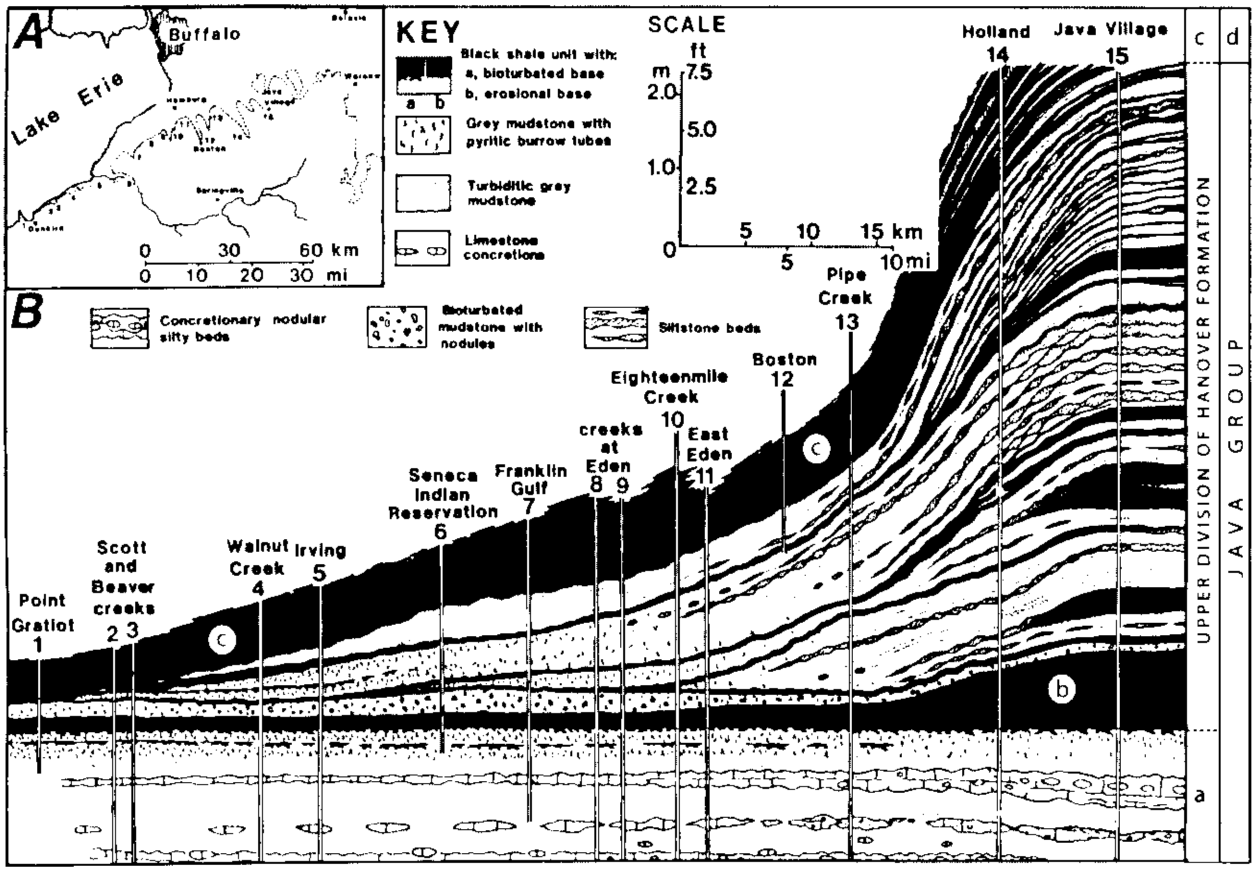

Figure 11: Regional stratigraphy of units within the upper part of the Hanover Formation across Chautauqua, Erie, and southwest Wyoming counties. Note conspicuous eastward thickening of the upper Hanover unnamed division of alternating thin gray and black shale with eastward splaying of units into a distal deltaic wedge and westward erosional overstep of underlying units by Dunkirk and upper Hanover black shale beds. Note also that the upper medial Hanover Formation below the newly named Point Gratiot Bed (= "Upper Kellwasser Bed") is notably more calcareous, bioturbated, and lighter colored than overlying units (see discussion in text). This figure is modified from Baird and Lash (1990) and Baird and Brett (1991) in that the Point Gratiot Bed is shown to be a division *within* the upper Hanover succession rather than the *base* of the Dunkirk Formation as shown in these earlier reports. Lettered units include: a, calcareous bed in upper medial part of Hanover Formation; b, Point Gratiot Bed; c, basal strata of Dunkirk Shale.

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ROADLOG AND STOP DESCRIPTIONS

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

Accumulated Miles	Incremental 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.
1.7	1.7	Exit I-90 (to the right)into feeder ramp for Route 400 Expressway. Proceed eastbound on Route 400.
2.15	0.45	Merge onto eastbound NY 400 from feeder.
3.7	1.55	Exit Route 400 expressway onto exit ramp for Union Road.
4.0	0.3	Junction with Union Road. Turn left (north) onto Union Road. Proceed north on Union Road to third light north of junction.
4.8	0.8	Turn right at red light onto Race Street opposite Indian Church.
4.9	0.1	Turn left from Race Street into parking area of Charles E. Burchfield Art Museum and Nature Center. Exit Vehicles and proceed to edge of Buffalo Creek.

STOP 1. Charles E. Burchfield Art Museum and Nature Center, Town of West Seneca (see Figs. 4, 5). When one of us (Baird) originally included this locality as a stop for a 1999 NYSGA fieldtrip (Baird et al., 1999), the present-day park was a vacant lot. The park has improved the access to this classic cutbank section along Buffalo Creek immediately upstream from Union Road. This stop is included, partly due to its relevance to our understanding of basinal submarine erosion processes, but also due to the fact that this stop was skipped owing to lack of time on the earlier fieldtrip. To reach the bank section we must wade across Buffalo Creek to the south-facing shale bank directly opposite the center. In the case of recent rains, the creek may be high, preventing our crossing. However, small, low exposures of the same channels are displayed at creek level on the south bank. These can be accessed in a high water scenario. At the bank, a prominent undulating contact is visible, separating gray to beige, calcareous mudstone below (lower division of the Levanna Member) from fissile, black shale above (medial part of Levanna Member; Figs. 4, 5). The undulating contact is an erosion surface which links eastward to a shell bed division of the Pompey Member of the Skaneateles Formation in central New York sections (see Baird et al., 2000). At this locality, conspicuous channel-like features are developed into the erosion surface which trend north-south, nearly perpendicular to the bank

trend (Fig. 5). The channels range from a few decimeters to 1.5 meters width and up to 0.5 meters in depth. The dark shale fills in channels sometimes show smaller, nested channels within larger ones (Fig. 5c) indicating that channel formation was a continuous process during formation and burial of the contact. Parallel, north-south alignment of channels suggests a prevailing current direction during channel formation (Fig. 5b). Axes of channels sometimes contain concentrations of brachiopod and trilobite debris admixed with fish teeth and bones. The channels are interpreted by Baird and Brett (1991) to be ancient examples of submarine, erosional furrows, *sensu* Flood (1983); furrows form from sustained, unidirectional currents and can form in a variety of aqueous settings. However, they are found to be particularly common at modern continental slope breaks (Flood, 1983). We believe that the lenticular outcrop profiles of Leicester- and other detrital pyrite accumulations are the lateral perspective view of similar, debris-filled channels where surrounding mudrock has dewatered and flattened out channel relief.

5.0	0.1	Return to junction of Race Street and Union Road. Turn left (south) onto Union Road and retrace route back to the NY 400 Expressway.
5.8	0.8	Westbound feeder ramp of the NY 400 Expressway. Enter it and proceed back to the New York State Thruway (I-90).
7.3	1.5	Feeder to I-90 (southbound) to Erie, Pa. Enter it by keeping to the left lane.
7.7	0.4	Merge leftward into main flow of southbound I-90.
8.35	0.65	Cross Cazenovia Creek
10.3	1.95	Lackawanna Toll Plaza of New York State Thruway. Continue straight.
11.3	1.0	Cross south branch of Smoke Creek.
12.05	0.75	Blasdell exit of Thruway. Enter exit feeder on the right.
12.35	0.3	Junction of I-90 exit feeder with Mile Strip Road; turn right (west) onto Mile Strip Road.
13.75	1.4	Mile Strip Road-NY 5 junction; turn right to enter junction rotary which will bear around to the left (south) for entry to NY 5 south-bound.
13.95	0.2	Exit rotary to the right onto NY 5 (southbound) entrance ramp.
14.05	0.1	Merge southbound onto NY 5. Ford plant on the left.
14.85	0.8	Major road splits to the left for town of Hamburg. Bear right (straight) and continue on NY 5.

15.55 0.7 Lake Erie visible to the right. Low shale bluffs along shore are exposures of the Ledyard Member of the Ludlowville Formation (Middle Devonian).

15.65 0.1 Enter town of Athol Springs. We will proceed southwestward through several small connected shore communities.

19.35 3.7 NY 5 junction with Lake Shore Road; bear right onto Lakeshore Road.

22.35 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.

22.65 0.1 Fishermen parking area below pull-off to the left immediately south of the Lake Shore Road bridge over Eighteenmile Creek and small roadcut on Lake Shore Road to the right. This is STOP 1 of tomorrows B3 Genesee Formation field trip (this volume).

22.8 0.15 Entrance to Frank Lloyd Wright Estate ("Graycliffs") on the right. This newly restored attraction in the Buffalo area was a major access route to the shore cliffs along the lake in the 1980s before the great ladder below the estate fell into disrepair.

24.55 1.75 Turn right into long private driveway immediately to the north of the Lake Shore Road bridge over Pike Creek; continue through the turnaround at the end of the driveway and park facing back toward the entrance. Do not block the driveway. Exit vehicles.

STOP 2. Lake Erie bluffs adjacent to the mouth of Pike Creek near Derby, Erie County (see Fig. 6). Proceed from end of long private driveway north of Pike Creek across yard to beach. Follow the beach southwest past Pike Creek to the beginning of a long bedrock cliff section bordering the beach. This section is in the southwestern part of a nearly continuous outcrop extending from Eighteenmile Creek almost to Sturgeon Point (STOP 4). Visible to the northeast are high cliffs exposing a long section, extending from the Wanakah Shale in the Hamilton Group, upward into the Frasnian Rhinestreet black shale. Units visible in the cliff south of Pike Creek, include: in ascending order, 2 meters of the Middle Devonian (Late Givetian) Windom Member, approximately 45 cm of lower Late Devonian (Frasnian) North Evans-Genundewa strata, 2.5 meters of gray and black shales of the West River Formation, and 2 meters of black Middlesex Formation. At this stop we will focus on the North Evans-Genundewa interval (Fig. 6).

This section shows the Windom Member-North Evans Limestone contact as a knife-sharp boundary separating chippy gray Windom shale rich in the small brachiopod *Emanuella praeumbona,* from dark, dysoxic beds of the Genesee Group (Fig. 6). The North Evans is anomalous in this area in that it is very thin and characterized by more detrital pyrite than typically found in sections closer to Buffalo. Furthermore, above the thin North Evans bed, and separating it from the overlying Genundewa Limestone, is a 25 cm-thick brownish black, flaggy shale unit that is unnamed (Fig. 6). This shale, containing flattened *Styliolina*, *Pterochaenia* , and wood debris, is very localized in distribution. At the North Evans type section on Eighteenmile Creek, adjacent to-, but immediately downstream from, the Amtrack railroad overpass, about four km east of STOP 2, the North Evans Limestone 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. 6). 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 Limestone 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. 6). In the next key section (Fig. 6) along the Old Lakeshore Road (to be seen by participants of the Sunday fieldtrip B3: this volume), the intervening shale is 10-11 cm-thick and the North Evans Limestone is only about 2-3 cm-thick. This intervening shale unit is herein interpreted as being a local basinal facies of the Genundewa Limestone in that its upper contact is conformable (non erosional) with the Genundewa Limestone. The westward North Evans allochem 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 2 than at localities further to the northeast.

At STOP 2, the North Evans Limestone rests on the Taghanic Composite Unconformity, a disconformity of large time-magnitude. Based on comparison with more continuous Devonian sections further east, the section at Lake Erie is severely truncated; approximately one third of the Windom Member, the entire overlying Tully Formation, and all of the succeeding Geneseo and Penn Yan formation successions are absent at STOP 2 (Fig. 2). The North Evans Limestone is a complex lag blanket famous for its fish material (Hussakoff and Bryant, 1918, Bryant, 1921, Turner, 1998) and conodonts (Hinde, 1879, Bryant, 1921, Huddle, 1974, 1981). North Evans conodonts are exceedingly abundant and diverse in species and types of elements. Elements of the North Evans fauna, both its fish debris and conodonts, can be traced from Erie County to the Genesee Valley. Preservation of the conodont elements is distinctive and varies from complete and pristine (light amber-colored) to broken, dark (almost black), and degraded (Color Alteration Index is 2 to 3). Colors of some of the fish debris are red, orange, gray and blue. The taphonomic history of the North Evans debris is complex and tests the limits of chronostratigraphic resolution (Kirchgasser and Koslowski, 1996; Kirchgasser and Vargo, 1998; Kirchgasser, 1994, 1998, 2001, 2002, 2004). The final taphonomic (burial age) of the North Evans material correlates to the youngest zone conodont in the mix, which is *Ancyrodella recta* of the upper part of Lower Frasnian MN Zone 2 (Kirchgasser, 1994); early whorls of the Lower Frasnian goniatite *Koenenites* (also MN 2 age) have been recovered from North Evans conodont residues at the type section at Eighteenmile Creek (Fig. 6a) and in lenses within the Genundewa Limestone at Linden in Genesee County (see Sunday illustrations). 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.

The Genundewa Limestone at STOP 2 is a 30-40 cm-thick ledge composed of styliolinid grainstone-packstone carbonate (Fig. 6). It is typically brownish gray, massive to nodular, limestone which sometimes weathers into thinner, flaggy beds. Aside from *Styliolina* and the small bivalve *Pterochaenia* , fossils are scarce, usually small, and of low diversity. The goniatites *Koenenites, Acanthoclymenia,* and *Tornoceras,* as well as *Manticoceras* at the very top, occur in the Genundewa, but are rare or poorly preserved here; the conodont *Ancyrodella recta* of upper MN Zone 2 occurs in the North Evans Limestone and at the base of the Genundewa Limestone at Linden in Genesee County (see Sunday illustrations). As noted, the Genundewa is a pelagic limestone that probably represents oxygen-stressed, sediment-starved, basin slope conditions. However, at this locality, local erosional channelization is evident locally within the limestone (Fig. 6). These channels, as well as pervasive small-scale hummocky cross-bedding and widespread alignment of *Styliolina* throughout the Genundewa, attest to significant current activity at the substrate, probably caused by deep-storm waves. The top of the Genundewa is gradational with the overlying shaley West River Formation; the topmost Genundewa becomes shaley and flaggy before giving way to the typical alternation of thin black and gray shale normally seen in the West River (Fig. 6). We herein interpret the interval from the sub-North Evans disconformity upward into the lower medial West River Formation is a Transgressive Systems Tract, starting with an erosional lowstand event recorded by the disconformity. The succeeding Genundewa is a condensed interval recording transgressive deepening within the basin and sediment-starvation on slope. A possible Maximum Flooding Surface is represented by a recurrent conodont-glauconite-bearing styliolinid bed within the basal West River Shale (Fig. 6); this conodont-rich bed has been traced westward from the Genesee Valley and is Huddle (1981) sample horizon 8122SD at Fall Brook, Geneseo (Kirchgasser et al., 1994, A-4, STOP 1, fig. 10). Early highstand facies are represented by succeeding alternations of black and gray shale. This overall transgression probably represents a hybrid eustatic and flexural event within the basin.

Board vehicles and drive to driveway entrance immediately to the north of Pike Creek. Turn right onto Lakeshore Road proceeding to the southwest.

24.6	0.05	Cross Pike Creek.
24.8	0.2	Sweetland Road-Lake Shore Road junction; bear right and continue straight on Lake Shore Road.
25.8	1.0	Turn right into private driveway (shore home). Park in available lots and exit vehicles.

STOP 3. Rhinestreet Formation at Lake Erie shore bluffs below at Seascape (private residence), 2 km northeast of Sturgeon Point near Derby, Erie County (see Fig. 7). Near-vertical shore cliffs between STOPS 2 and 3 prevent our seeing units (Middlesex, Cashaqua formations) between the West River shale and the Rhinestreet shale. We will, however, see the top of the Cashaqua at STOP 5. STOPS 3 – 5 are directed to features in the lower part of the Rhinestreet Formation. Proceed across private yard to steps leading down the shore cliff. Turn

right and proceed northward (down-section) along the beach to exposure of basal Rhinestreet strata.

The Rhinestreet Formation is one of the thickest Late Devonian black shale divisions in western New York. Hard, well-jointed, black shale makes up most of this section. Less organic-rich, recessive weathering dark gray shale intervals, as well as, beds of greenish gray shale, can also be seen (Fig. 5). Conspicuous at several levels within the black shale intervals are large, often massive, septarial concretions. After walking northward on the beach, we will stop at a level displaying the largest concretions which occur about two meters below a 2.2 meter-thick gray shale unit (Fig. 7). The black shale facies within the Rhinestreet records intervals of severe dysoxia to near-anoxia within the Devonian basin associated with a broad time interval associated with global sea level highstand (Johnson et al., 1985). This organic-rich lithofacies accumulated in a relatively deep-water, stratified basin setting west of the prograding Catskill Delta in a foreland basin already maintained by collisional thrust loading (Ettensohn, 1998; see Fig. 1). Contemporaneity of Catskill Delta progradation is splendidly shown by the eastward splaying of Rhinestreet black shale divisions into the deltaic clastic wedge and by eastward passage of organic-rich basinal facies into shoreward, coarse, fossiliferous neritic facies and terrestrial red beds (Woodrow and Sevon, 1985; see deWitt, 1960; deWitt and Colton, 1959; Colton and deWitt, 1958; Sutton, 1963, and Kirchgasser et al., (1994) for evolution of correlations and unit terminology pertaining to eastern Rhinestreet and other West Falls Group subdivisions). The 2.3 meter to 2.4 meter-thick gray shale unit above the band of large concretions is the western distal "toe" of a progradational clastic pulse extending westward from the delta complex; this fine grained turbiditic or hemipelagic sediment was probably deposited during a sea level lowstand event which allowed prodelta muds to be exported far into the basin (Fig. 1). A turbiditic origin for part of this interval is suggested by the presence of a 2 – 5 cm-thick siltstone bed at its basal contact at STOPS 3, 4, and 5 (Fig. 7); the basal surface (sole) of this layer displays erosional groove cast impressions and the top of the bed fines upward into featureless gray shale, suggestive of a turbiditic event. At STOP 3 (Seascape section), the basal lag of the siltstone bed yields conodonts of MN Zone 7 (Levin and Kirchgasser, 1994; Kirchgasser et al., 1994; Kirchgasser and Klapper, 1992). About one meter below the green-gray shale unit is a recessive notch that marks the position of a K-bentonite layer (Fig. 7). This altered ash bed is characterized by gray brown clays (kaolinite and mixed layered clays), bleached (pyroclastic?) micas, and secondary pyrite with minor quartz, calcite, plagioclase and ?apatite. The ash bed is graded with clay flakes in the upper part with even stronger parallel orientation than the clays in the overlying black shale. Lenses with the distinctive color and fabric of the ash occur intermittently for a few centimeters above the ash bed. As noted above, this ash bed is apparently not the Belpre Ash Bed of Tennessee (conodont MN Zone 8, Rotondo and Over, 2000) but an earlier event within the interval of MN Zone 7); the Belpre Ash has a radiometric date of 381.1 +/- 3.3 Ma (Tucker et al., 1998; Kaufmann, 2006).

Return to vehicles and exit to driveway junction with Lakeshore Road; turn right onto Lakeshore Road and continue to the southwest.

26.9 1.1 Junction of Lake Shore Road with Sturgeon Point Road; turn right (northwest) onto Sturgeon Point Road.

27.6 0.7 Enter Sturgeon Point Park and boat marina complex. Enter to the left and follow the road around to the northeast end of the complex.

27.95 0.35 Arrive at northeastern limit of parking area. Park and exit vehicles.

STOP 4. Rhinestreet Formation in Lake Erie shore bluff succession, both to the northeast of-, and southwest of, the Sturgeon Point marina and car park complex near Derby, Erie County (see Fig. 7). We will, first, proceed on foot from the northeast end of the car park to the beach and follow the beach and continuous shale cliff section to a position near the outflow pipes from the Derby waterworks. The bluff section is nearly the same as that for STOP 3, except that most of the black shale interval below the gray shale unit is below lake level. The K-bentonite is not accessible here, but the gray shale unit is much easier to examine at this outcrop. Moreover, the black shale interval above the gray unit can be examined here (Fig. 7).

Within the gray shale unit in this locality are very thin, 0.2 – 6 cm-thick, black shale beds that often display sharp contacts and strong visual definition within the thicker gray succession. Buff gray concretions occur at two levels within the gray shale interval; these are concentrated closely below black shale bands and appear to be controlled by the presence of the bands. However, in a few places along the exposure, the thin, overlying black shale bands pinch out over the tops of the subjacent nodules. This suggests that concretion growth may have created differential paleorelief , perhaps due to early dewatering and differential settling of mud. The sharply defined thin, black bands pose an interesting question: Do they represent slow background deposition between turbiditic gray mud pulses, or do the thin black bands, themselves, represent some alternative type of rapid depositional event involving sedimentation, or resedimentation, of organic-rich sediment? Is it possible that the organic-rich sediment, instead, may have been originally pelletal, hence mobile and easily transported on the seafloor? This latter scenario, yet untested, could explain these sharp pinstripe bedforms as rapidly deposited, current-traction-generated features.

To the immediate northeast of the second waterworks outlet is a problematic structural displacement or offset at the level of the gray shale unit. At the lake edge, several fractures in the lower black shale division can be seen that are filled with gray shale that displays soft-sediment shearing and fracturing. Directly across from the area of shore fractures in the cliff face the gray shale unit thins to less than a third of its normal thickness across a distance of about 80 meters. However, debris on the beach conceals the intervening area and the full nature of this structure. The shore cliff and lake edge exposure displays excellent examples of joint networks, particularly for the black shale bands. These joints are believed by Gary Lash to have evolved during thermal-burial maturation of the black shale unit as the black shale units began to function as hydraulic top seals for moving fluids migrating up from below (see Lash, 2006; Lash and Blood, NYSGA Sunday trip B1, this volume). The different orientations of the various joint sets are believed to correlate to a series of far-field stress phases associated with the Allegheny orogeny (Lash and Blood, Sunday trip B1, this volume). This outcrop will be important as a stop on that Sunday trip.

Between 40 and 45 cm above the gray shale interval, within black shale facies, is a styliolinid-rich, hashy layer that is associated with widely-spaced, spheroidal concretions (Fig. 7). Close examination of the layer shows the presence of numerous, flattened goniatites (some partially pyritized), spotty concentrations of *Styliolina*, fish debris, large horizontal (arthropod?) trace fossils and scattered conodonts. The goniatites first identified during a survey of this section this past June, belong to the genus *Naplesites* in the family Beloceratidae. The lineage is characterized by compressed (discoidal), evolute shells with increasingly numerous, distinctly pointed lobes (and saddles) forming chevron-like patterns. The ancestor of the family is *Probeloceras* which in New York occurs below the Rhinestreet in the Cashaqua Shale (Sonyea Group; MN Zone 5); the group culminates with the extremely multilobed *Beloceras*, a genus still unknown in North America (Fig. 3). The discovery of the *Naplesites* horizon at Sturgeon Point (Stop 4) is important in that its presumed position in the lower Rhinestreet (House and Kirchgasser, 1993) is confirmed and the conodonts in the bed may prove to be datable. *Naplesites* is otherwise rare in New York and is known only from a few specimens (two species) described by Clarke (1898) far to the east from unspecified horizons and sections in the shales around Naples in Ontario County (Canandaigua Lake meridian). *Probeloceras* and *Naplesites* (as *Mesobeloceras*) are illustrated in Kirchgasser, Over and Woodrow, 1994, fig. 7).The close stratigraphic coincidence of useful conodonts, *Naplesites*, and the K-bentonite bed is important geochronologically and is the subject of ongoing work.

Return to vehicles and proceed by car around to the southwestern most parking area near the Sturgeon Point pier.

28.35 0.4 Park and exit vehicles.

Proceed on foot to beach below car park and follow beach southwestward for approximately 120 meters to a low outcrop bench of black Rhinestreet shale at the lake edge.

This exposure of black shale is probably stratigraphically higher than the accessible beds northeast of the marina owing to regional dip effects, but the precise match of beds can not yet be made owing to the long covered interval between the two sections. Notable in this outcrop are several bands of concretions including a line of massive septarial concretions below the bench of very resistant black shale. At the top of the black shale bench are two closely-spaced horizons of small spherical to ellipsoidal, 0.3 – 4 cm-diameter, phosphatic nodules. Phosphatic nodules, well known from the upper part of the New Albany Shale and the Cleveland Shale, have not been reported from the Rhinestreet. The occurrence of nodules of this type has been interpreted as evidence of nutrient upwelling and high productivity in surface waters (see Robl and Barron, 1989). What is striking here is that many, if not most, of the nodules are nucleated by fish spines and scales. Small, sand-size grains within some of the nodules may be radiolarian tests.

Return to vehicles and follow one-way road around to exit of Sturgeon Point Marina.

28.7 0.35 Exit Sturgeon Point Marina and proceed southeast on Sturgeon Point Road.

29.4 0.7 Junction of Sturgeon Point Road with Lake Shore Road; continue straight on Sturgeon Point Road.

30.4 1.0 Junction of Sturgeon Point Road with NY 5; continue straight on NY 5.

33.55 1.25 Junction of Sturgeon Point road with US 20. Turn left and proceed to the northeast on US 20.

35.3 1.75 Junction of US 20 with Shadagee Road immediately southwest of US 20 bridge over Eighteenmile Creek. Turn right onto Shadagee Road.

35.35 0.05 Park vehicles by North Evans cemetery on the right. Depart vehicles.

STOP 5. Cashaqua Shale/Rhinestreet Shale contact and overlying Rhinestreet strata exposed on Eighteenmile Creek and on access road leading to that creek, town of North Evans, Erie County (see Fig. 7). Enter access path opposite from North Evans Cemetery. Proceed on foot down sloped path to valley bottom. Cross flat area to edge of Eighteenmile Creek.

The Cashaqua Shale Formation of the Sonyea Group in southern Erie County is characteristically composed of gray fissile shale with a rhythmic succession of discoidal concretion bands (Buehler and Tesmer, 1963; Kirchgasser et al., 1997, fig. 9). The fauna of this unit consists of small mollusks and brachiopods, indicative of a dysoxic setting. Most notable, is the occurrence of numerous, often poorly preserved, goniatites belonging to the genera *Manticoceras* and *Probeloceras* which are flattened outside of the concretions and variably three dimensional inside of them (conodont Zone MN 5). *Probeloceras* is the ancestral genus of the family Beloceratidae and is followed by the genus *Naplesites* in the Rhinestreet Shale seen at Sturgeon Point, Lake Erie (Stop 3; see Kirchgasser, Over and Woodrow, 1994, fig. 7 for illustrations of Sonyea and West Falls Group goniatites). The prominent concretion 3ayer with MN Zone 6 conodonts in the dark shales of the upper Cashaqua Shale is a septarian band with white or pink barite filling the shrinkage cracks and in places east of the Genesee Valley in Livingston County, replacing the shells of a rich molluscan fauna including the goniatites *Manticoceras*, *Prochorites*, *Acanthoclymenia* and *Aulatornoceras*; conodonts in the bed indicate MN Zone 6. The *Prochorites* is a species (*P. alveolatus*) known elsewhere only in Western Australia.

We will see the contact of this unit with the overlying Rhinestreet Formation of the West Falls Group in the bed of Eighteenmile Creek. The base of the Rhinestreet is sharp and marked by a seam of diagenetic pyrite which weathers to a rusty band in bank sections. No detrital pyrite has been found on the contact, but a rich association of conodonts is reported from the basal few centimeters of black Rhinestreet shale (Huddle, 1968; Kirchgasser and Klapper, 1992; Klapper et al., 1995).

Ascending the access path as we return to the vehicles, we pass the same lower Rhinestreet gray shale division that we examined at STOPS 3 and 4. Along the path this section is weathered and slumped, but, on the other side of Eighteenmile Creek, an excellent profile through this interval can be seen on a side tributary waterfall (Fig. 7).

Board vehicles and turn cars around. Return to Shadagee Road/Route 20 intersection.

35.4 0.05 Shadagee Road/ US 20 intersection. Turn left (to southwest) on US 20.

37.15 1.75 Junction of US 20 with Sturgeon Point Road; continue to southwest on US 20.

39.25 2.1 Junction of US 20 with Eden-Evans Center Road; turn left (east) on Eden-Evans Center Road.

39.95 0.7 Eden-Evans Center Road crosses over New York State Thruway (I-90).

40.6 0.65 Entrance to the Thruway on the left; continue straight (east) on the Eden-Evans Center Road.

43.9 3.3 Intersection of Eden-Evans Center Road with NY 62 in Eden; Continue straight (east); the road name changes to Church Street.

45.2 1.3 Intersection of Church Street with Jennings Road; continue straight (east) on Church Street. Church Street soon bends to southeast as the Road descends into the valley of the south branch of Eighteenmile Creek.

46.35 1.15 Church Street bridge over the south branch of Eighteenmile Creek.

46.5 0.15 Turn right onto Old Mill Road (a dead-end lane) and continue to its end.

46.65 0.15 Exit vehicles at end of Old Mill Road.

STOP 6. Section of Pipe Creek Formation ("lower Kellwasser Bed") and synjacent units at waterfall along south branch of Eighteenmile Creek, southeast of Eden, Erie County (see Figs. 8, 9). Proceed on foot from the vehicles to the lip of the large waterfall. The gray, silty, bioturbated unit in the falls face is the top part of the shaley Angola Formation of the West Falls Group. This is abruptly capped by the resistant, black, and well jointed Pipe Creek Formation of the Java group (Fig. 8) that forms the erosional lip of the waterfall. The 1.6 meter-thick Pipe Creek succession is followed upstream in the floor of the creek by softer, nodule-rich, gray and black shale facies of the Hanover Formation (Fig. 8).

The black Pipe Creek shale consists of massive, organic-rich facies that contrasts markedly with both the underlying Angola and overlying Hanover. The base of the Pipe Creek is abrupt on the Angola with the development of abundant diagenetic pyrite in the uppermost Angola. No erosional, detrital pyrite has been found at the contact, but a profound change in microtexture is seen as one passes from the bioturbated, pyrite- suffused, uppermost Angola, into the laminated, black Pipe Creek (Fig. 9). As noted in the text, this unit has now been found to correlate to the "Upper Kellwasser Bed" which marks a major ecological reorganization and extinction event in global sections.

In the process of measuring this section for this field trip, we found an apparent K-bentonite bed 15 cm below the top of the Pipe Creek (Fig. 8, unit e). This layer consists of approximately 1 cm of soft clay rich in pyroclastic mica. The bed is currently being analyzed for its geochronostratigraphic potential (see text).

Above the Pipe Creek shale, there is an abrupt change to softer, gray shale that abounds in small concretionary nodules through an interval of about 1.5 meters (Fig. 8). One bed (Fig. 8, unit g), is packed with very small irregular nodules such that this layer somewhat resembles a muddy version of the classic condensed, gray, nodular limestone facies of European sections (Tucker, 1974; Tucker and Kendall, 1973). Fossils are common in the lower Hanover, but are usually very small. Diminutive gastropods, bivalves, and ostracodes make up most of the faunal trail mix. Goniatites, important as chronostratigraphic markers, occur sparingly in this interval at this section. However, at Java Village in Wyoming County, *Delphiceras* occurs just above the top of the Pipe Creek and somewhat higher in the section at Walnut Creek. At Silver Creek in Chautauqua County *Sphaeomanticoceras* and *Crickites* can be found, the latter genus being the highest zonal indicator of the Frasnian Stage (Fig. 3; House and Kirchgasser, 1993).

Board vehicles and return to junction of Old Mill Road with Church Street.

46.8	0.15	Turn right onto Church Street immediately west of Church Street-NY 75 intersection.
46.85	0.05	Junction of Church Street with NY 75 (Sisson Highway); turn right on NY 75 and continue to the southeast.
47.8	0.95	NY 75 crosses over south branch of Eighteenmile Creek. Gray mudstone deposits of the Hanover Formation are visible in upstream cutbank exposure to the left.
48.15	0.35	Junction of NY 75 with New Oregon Road which splits off to the left; turn left onto New Oregon Road.
48.4	0.25	New Oregon Road bridge over south branch of Eighteenmile Creek; park cars on shoulder near bridge and exit vehicles.

STOP 7. Upper part of Hanover Formation showing "Upper Kellwasser Bed" (Point Gratiot Bed) and basal contact of Dunkirk Formation on south branch of Eighteenmile Creek below New Oregon Road bridge, southeast of Eden, Erie County (see Figs. 10, 11). Exit vehicles and proceed to the downstream end of a long, west-facing cutbank along the south branch of Eighteenmile Creek below the New Oregon Road overpass. At this point gray shale of the upper middle part of the Hanover Formation are abruptly overlain by the black Point Gratiot Bed and succeeding gray and black shale beds of the upper part of the Hanover Formation (Fig. 10).

At this locality the Point Gratiot Bed is a black ledge that correlates to the "Upper Kellwasser Bed" of Late Devonian sections globally (see text). The topmost part of this ledge marks the actual Frasnian-Famennian extinction event of literature based on conodont work in western New York sections (see Over, 1997, 2002; Day and Over, 2002). Although the bed is composed of basinal black shale, fossils such as the probable anaptychus organ *Spathiocaris* , fish material, and wood debris can be found, particularly near the top of the bed. Moreover, elevated levels of Platinum Group elements occur at this level and other horizons in the boundary interval black shales (see Over et al., 1997).

Above the Point Gratiot Bed in this section is a 2.2 meter-thick upper Hanover succession of alternating gray and black shale beds that is capped by the black, well jointed Dunkirk Shale at the top of the bank (Fig. 10). The upper Hanover interval closely resembles the lower Rhinestreet gray shale unit owing to several discrete, thin, black shale bands which contrast sharply with the thicker gray lithology. Reworked pyritic burrow clasts and exhumed geopetally pyritized *Tasmanites* half-spheres (*sensu* Schieber and Baird, 2001) have been found in thin lags at the base of the thin black beds and at the base of the Dunkirk Shale. Immediately above the Point Gratiot Bed in this section is a thin, gray, biotubated shale bed yielding small nodules (Fig. 10). Above this level, gray shale units become less visibly bioturbated and more non calcareous, suggestive of a long-term transgressive trend in the interval. Hanover deposits below the Point Gratiot Bed are markedly more calcareous, lighter colored, and more intensely bioturbated; upward changes across the Point Gratiot Bed probably reflect combined effects of transgressive deepening in the basin and adverse biological effects associated with the Frasnian-Famennian crisis. Participants should look for any sign of the fossiliferous "recovery bed" discovered by Jeff Over approximately one meter above the Point Gratiot Bed near Java Village (Day and Over, 2002). Although it is absent from many area sections, the STOP 7 outcrop has not yet been seriously checked for the presence or absence of this unit.

Board vehicles and retrace route to entrance of New York State Thruway.

55.9	7.5	New York State Thruway (I-90) entrance from Eden-Evans Center Road. Enter onto Thruway and return to Adam's Mark Conference Center.

End of field trip.