DACRYOCONARID BIOEVENTS OF THE ONONDAGA FORMATION AND THE MARCELLUS SUBGROUP, CHERRY VALLEY, NEW YORK

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INTRODUCTION

The Order Dacryoconarida Fisher 1962 is a taxon of extinct and enigmatic conical microfossils that occur in marine strata of the Devonian System. Although the taxonomic status of the group and its phylogenetic affinities are not universally agreed upon, unequivocal dacryoconarids (dacs) range from upper Lochovian strata to the Frasnian-Famennian mass extinction boundary. Regardless of their biologic affinities, the organisms themselves are understood to have been marine animals, which were predominantly planktic in habit and pelagic in habitat.

Within the region of the Old Word Realm, the dacs are represented by more than thirty genera and scores of species from which sets of biozones have been developed rivaling those of the conodonts in their detail and temporal resolution (see Lutke, 1979, 1985; Alberti, 1993; Oliver and Chlupac, 1991; Weddige, 1998). Old World dacs are also diagnostic of several Devonian bioevents, most notably for present purposes the lower Eifelian Chotec Event and the upper Eifelian Kacak-*otmari* Event(s). Such is not the case in the Devonian of eastern North America where the dacs have been afforded little attention, and the stratigraphic ranges of the few known species are themselves incompletely documented. It is the purpose of this field trip to introduce participants to dacryoconarid genera and bioevents as they are currently understood to be recorded in the Onondaga Formation and the Marcellus Subgroup at Cherry Valley, New York (CVNY).

STRATIGRAPHIC SETTING

The focus to this field trip is the occurrence of dacryoconarids within the interval of the Onondaga Formation and the Marcellus Subgroup as they are known from a nearly complete composite section of exposures (Fig. 1) on and adjacent to U.S. Route 20 at Cherry Valley, New York (Sprout Brook, NY. 7.5' quad.). Descriptions of the subjacent Esopus and Carlisle Center (= Schoharie) Formations are provided to broaden the biostratigraphic picture and to facilitate the reporting of dacs, which have recently been discovered in these units at other localities. The lithostratigraphic terminology used herein is an amalgam of that used by Rickard (1975, 1981) and a set of revisions proposed by Ver Straeten and Brett (1995). See Oliver and Klapper (1981), Anderson et al. (1986), or Griffing and Ver Straeten (1991) for additional information on these units and outcrop locality.

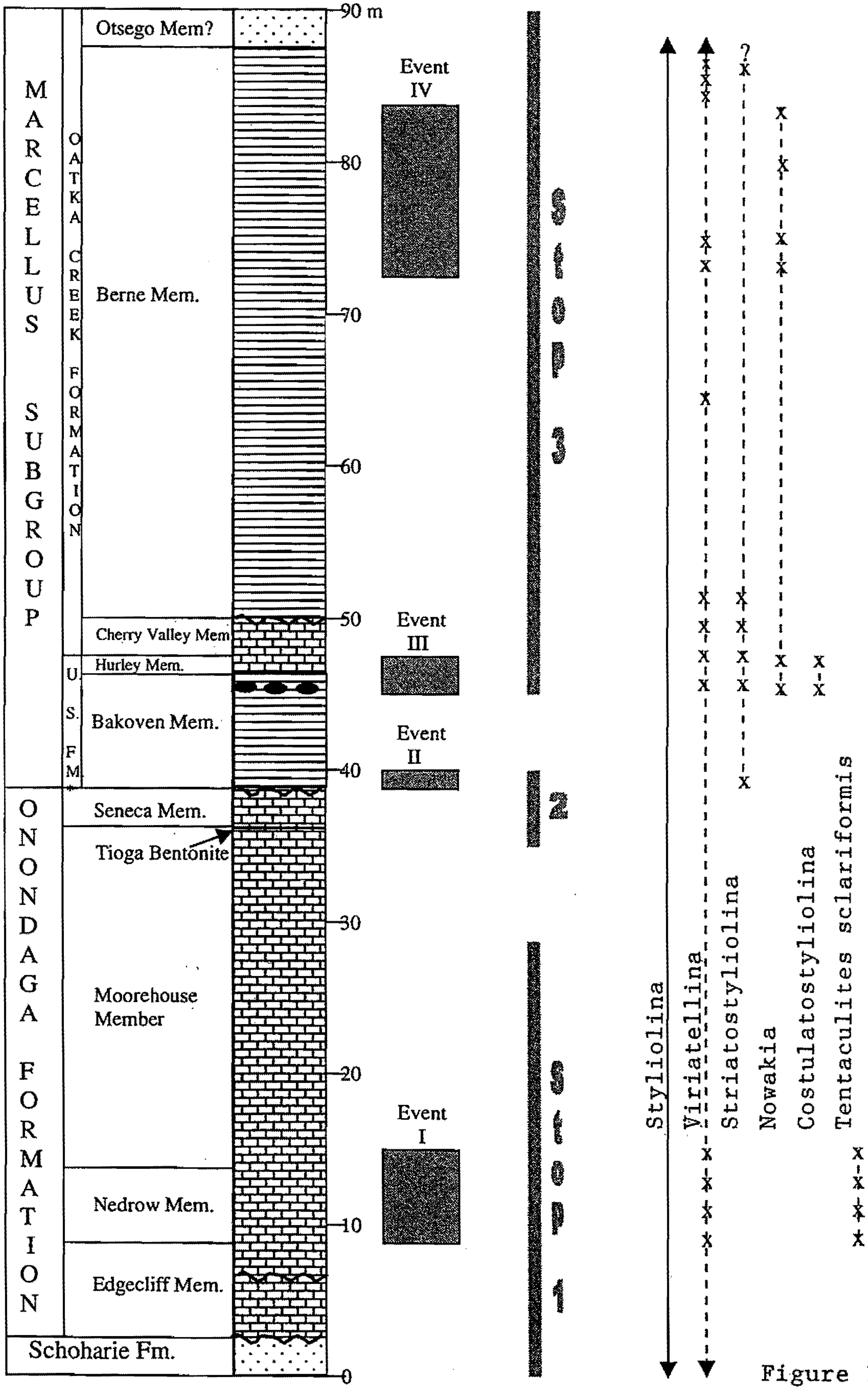
Esopus Formation

This is a 7 m thick unit of dark gray shale and medium bedded, gray to black chert (Fig. 1). Whereas the chert contains a sparse and poorly preserved set of gastropods and brachiopods, the ichnofossil *Zoophycos* abounds in the shale (Rickard and Zenger, 1964). *Chondrites*, tsamanitids and rare specimens of *Tentaculites* are also present in the shale at CVNY, and siliceous sponge spicules have been observed in thin sections of the chert. Dacryoconarids are currently unknown from the Esopus at this locality, as well as from all units beneath it.

Carlisle Center Formation

This is a 14 m thick unit of buff-weathering, medium-gray, calcareous, glauconitic, fine-grained quartz arenite (Fig. 1). The strata were pervasively bioturbated by *Zoophycos* in conjunction with a diversity of vertical burrowers. Both the lower and the upper contacts of the unit are abrupt and disconformable.

The Carlisle Center of Rickard (1975) is deemed to be a member-rank condensed equivalent of the Schoharie Formation (Ver Straeten and Brett, 1995). Although Johnson et al. (1985) regarded both the



90 m
80
70
60
50
40
30
20
10
0
MARCELLUS SUBGROUP
OATKA CREEK FORMATION
U. S. FM.
ONONDAGA FORMATION
Otsego Mem?
Berne Mem.
Cherry Valley Mem
Hurley Mem.
Bakoven Mem.
Seneca Mem.
Tioga Bentonite
Moorehouse Member
Nedrow Mem.
Edgecliff Mem.
Schoharie Fm.
Event IV
Event III
Event II
Event I
Stop 3
2
Stop 1
Styliolina
Viriatellina
Striatostyliolina
Nowakia
Costulatostyliolina
Tentaculites sclariformis

Figure 1

Esopus and the Carlisle Center to be correlative with Transgressive-Regressive (T-R) Cycle Ib, they regarded the Schoharie and its western New York/Ontario equivalent, the Bois Blanc Limestone, to represent the transgressive phase of T-R Cycle Ic. Acknowledging that there are uncertainties in precise correlation between the Carlisle Center and its Schoharie-Bois Blanc equivalents, particularly in its upper contact, the entire interval is regarded to lie within the *Polygnathus serotinus* conodont zone (Klapper, 1981). Thus, according to the criteria of Ziegler and Klapper (1985) and Oliver and Chlupac (1991), the Carlisle Center is referred to the upper Emsian Stage of the Lower Devonian Series.

Onondaga Formation

This unit is a 37m interval of limestones and chert (Fig. 1), which is divided into four members (Oliver, 1954, 1956) described here in ascending order. The Onondaga is correlative with T-R Ic (Johnson et al., 1985).

The Edgecliff Member typically consists of thick- to massive-bedded, light-gray, coarse-grained grainstones and packstones. The basal bed of the Edgecliff contains well-rounded quartz sand, glauconite, and phosphate nodules. These nodules range in size from granules to cobbles and usually bear numerous borings. Some sectioned specimens show concentric generations of phosphitization and boring, suggesting a polycyclic history of deposition and exhumation prior to final burial. These observations have bearing upon the magnitude and history of the unconformity at the Carlisle Center-Edgecliff contact, which have yet to be satisfactorily worked out. The uppermost bed of the Edgecliff is a packstone (poorly washed biosparite), which contains large (0.5-1.5 cm) nodules of iron pyrite. This appears to be a hardground surface and to represent a minor unconformity at the top of the member (Wolosz et al., 1991).

The lowermost bed of the Nedrow Member is a laminated, argillaceous wackestone (fossiliferous micrite), which abruptly overlies the uppermost Edgecliff. This lowermost argillaceous Nedrow bed is a meter-scale interval, which grades upward into a cleaner wackestone (sparse biomicrite). This coarsening-upward cycle is repeated twice at this locality and five or more times at localities in central and western New York. Based on observations of the member in central New York, Oliver (1954, p. 633) referred to the more argillaceous Nedrow facies as "Zone D" and the coarser-grained facies as "Zone E" and reported a particularly diverse and abundant ostracode fauna in the former. For present purposes it is noteworthy that Oliver (1954, 1956) did not report the occurrence of *Tentaculites scalariformis* within the Nedrow from any locality in the state. Rickard (in Oliver and Klapper, 1981) reported the co-occurrence of the conodonts *Polygnathus costatus patulus* and *P. costatus costatus* 2.3-2.6 m above the base of the Nedrow at CVNY. The stratigraphic overlap of these two taxa occurs only in the lower part of the *costatus* Zone and above the first occurrence of *P. costatus partitus* (Ziegler and Klapper, 1985), an index taxon that is not know to occur in New York (Klapper, 1981).

The Moorehouse Member is an interval of medium-bedded, medium- to dark-gray wackestones and mudstones that contain nodules and thin beds of dark-gray to black chert. At CVNY, the lower Moorehouse includes two sub meter-scale coarsening upward intervals, which are reminiscent of the Nedrow cycles below, though the Moorehouse cycles are thinner and less argillaceous than their Nedrow counterparts. This theme is repeated again higher in the member. Working in the formation's type area of central New York, Oliver (1954, p. 628) referred to the fine-grained intervals of the Moorehouse as "Zone G," and noted that this facies marked a return to a Nedrow-like "Zone D" environment. In the "Zone G" faunal list Oliver (1954, p. 634) reported an abundance of ostracodes, the inarticulate brachiopod *"Discina" minuta*, and very rare specimens of *Tentaculites scalariformis.* The upper beds of the Moorehouse at CVNY are thickly-bedded, light- to medium-gray packstones. The Moorehouse is separated from the atypical massive, medium-gray packstones and grainstones of the Seneca Member by the Tioga Bentonite (= Tioga B of Way et al., 1986). The Seneca is disconformibly overlain by the Bakoven Shale. Although this contact is not exposed at Cherry Valley, NY, it is (sometimes) observable nearby at Optional Stop A and in proximity to Optional Stop B.

Figure 1. Stratigraphic section of interest at Cherry Valley, New York showing lithostratigraphic units, Dacryoconarid Event intervals, field trip stop intervals, and the local range zones of selected dacryoconaids plus *Ttentaculites scalariformis.* Note: The ~~~~ symbol shown in the Edgecliff Limestone should be at be at the Edgecliff-Nedrow contact.

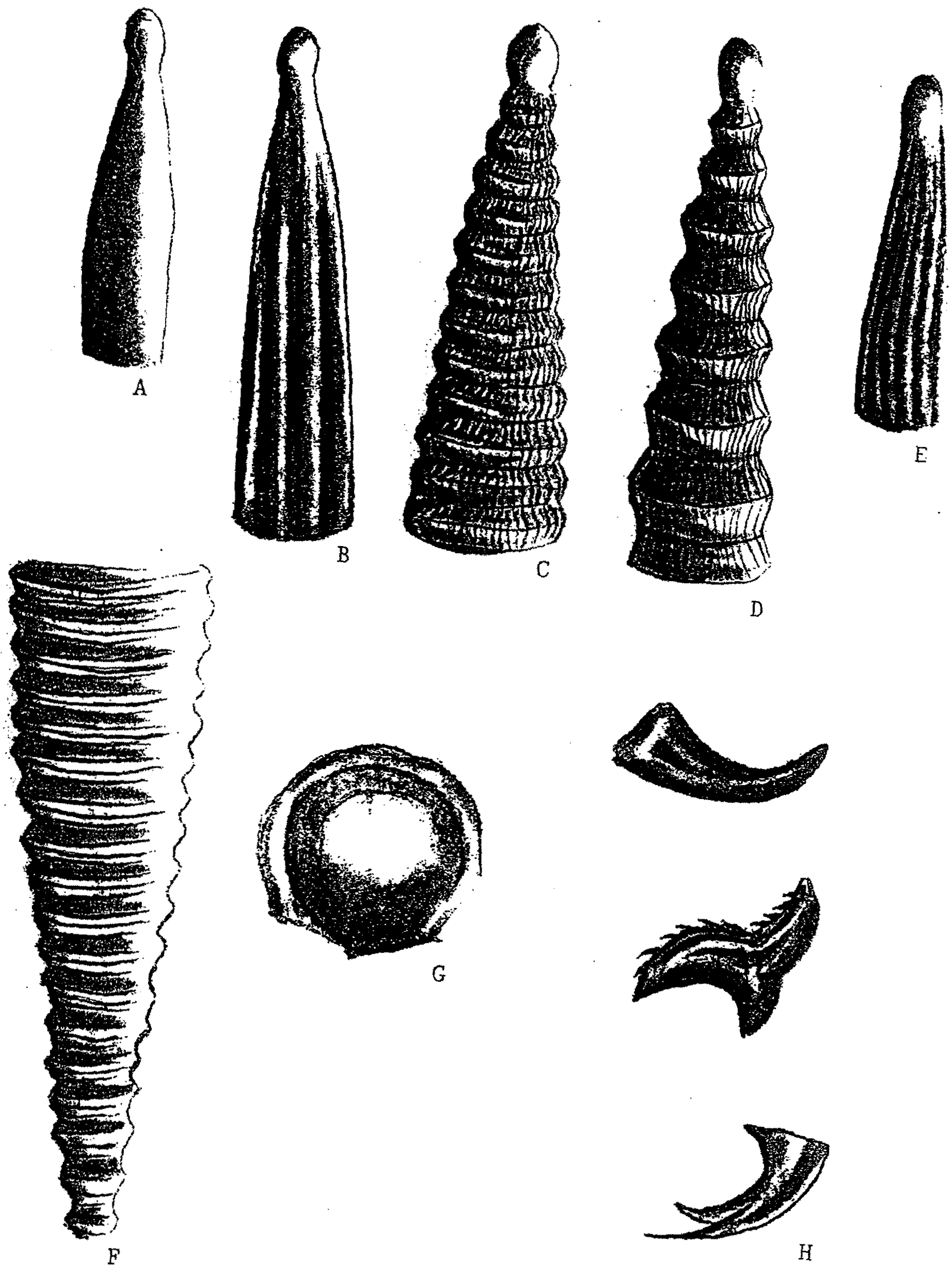


Figure 2

Marcellus Subgroup

In the traditional lithostratigraphic terminology of New York, the Onondaga Formation is overlain by the Marcellus Formation, the basal unit of the Hamilton Group (Rickard, 1975, 1981). Within this classification, the Union Springs Member is the lowermost shale unit of the Marcellus Formation throughout much of the state. The upper Marcellus shale unit is referred to as either the Oatka Creek, Chittenango, or Mount Marion depending on whether one is working in the western, central, or eastern parts of the state. Sandwiched between the two shale units is the Cherry Valley Limestone of Rickard (1952), which was originally referred to as the "Goniatite limestone" by Vanuxem (1842).

Ver Straeten et al. (1994) proposed a revision to this traditional hagiography in which the Marcellus is elevated in rank to "subgroup" status and both Union Springs and Oatka Creek (= Mount Marion) are elevated to the rank of "formation" (Fig. 1). Accordingly, at CVNY, the Union Springs Formation includes the Bakoven and Hurley Members (Fig. 1). The Bakoven Member is a carbonaceous black shale with calcareous concretions in its upper 1.5 m. At this location, the Hurley Member includes a lower 10-25 cm interval of packstone and an upper 3-8 cm interval of gray to black shale, which Ver Straeten and Brett (1995) refer to respectively as the Chestnut Street and Lincoln Park submembers. The Bakoven Member is assigned to the *Tortodus kockelinaus australis* conodont zone and, the Hurley Member lies within the lower part of the *T. kockelinaus kockelianus* zone (Klapper, 1981). The Union Springs Formation, as a whole, was deposited during T-R Cycle Id (Johnson et al., 1985). Both conodonts and stratigraphic sequences place the Union Springs within the Eifelian Stage of the Middle Devonian Series (Woodrow et al., 1988).

The Oatka Creek Formation is the upper shale unit of the Marcellus subgroup in western and central New York. Its eastern New York equivalent is the Mount Marion Formation. Throughout much of the state, the base of both units is the Cherry Valley Member (= Cherry Valley Limestone of Rickard, 1952). The superseding Berne Member is a carbonaceous black shale, which is overlain by the coral-rich Halihan Hill Bed, which marks the base of the arenitic Otsego Member. Although the Halihan Hill Bed has not been observed at this locality, specimens of *Nowakia*, which are comparable to those known from this bed at other localities, have been collected here. Although conodonts are poorly known from the Oatka Creek, the formation has been inferred to lie within the *T. kochelianus kochelinaus* zone (Klapper, 1981). Johnson et al. (1985) refer the Oatka Creek to T-R Cycle Ie and the overlying Skaneateles Formation to T-R Cycle If.

STAGE BOUNDARIES AND GLOBAL BIOEVENTS

The Lower Eifelian Chotec Event

The Global Stratotype Section and Point (GSSP) for the base of the Eifelian Stage is in the Eifel Hills of Germany at the first occurrence of the conodont *Polygnathus costatus partitus* (Ziegler and Klapper, 1985). *P. costatus partitus* is the second in a lineage of *P. costatus* subspecies with *patulus* occurring first and *costatus* third. The basal Eifelian GSSP lies within strata deposited during T-R Cycle Ic only a little below a eustatic deepening known as the Chotec Event (Chulpac and Kukal, 1988; Walliser, 1995; Weddige, 1998). The strata of Europe and north Africa, which were deposited during the Chotec Event, record a facies shift from light-colored, coarse-grained sediments to darker colored shales or dark, argillaceous limestones that contain an abundance of the dacryoconarids *Styliolina* and *Nowakia*.

The base of the Eifelian Stage in the strata of eastern North America is indeterminant due to the absence of the index conondont *P. costatus partitus.* The association of *P. c. patulus* and *P. c. costatus* in the upper beds of the Nedrow Limestone provides an uppermost constraint on the potential horizon for the Emsian-Eifelian boundary. Local tradition combined with this constraint have led to the tentative placement of the boundary either at the base of the Edgecliff Limestone or as high as the base of the Nedrow (Woodrow et al., 1988; Kirchgasser and Oliver, 1993).

Brett and Ver Straeten (1994) reported the occurrence of two laterally continuous beds of black shale at the contact of the Nedrow and Moorehouse Limetones in central New York and discussed the

Figure 2. Paleobiogeographic occurrences of selected dacryoconarid index species during the Emsian (Fig. 2A) and the Eifelian-Givetian (Fig. 2B) intervals. Modified from Johnson and Boucot (1973) by Lutke (1979).

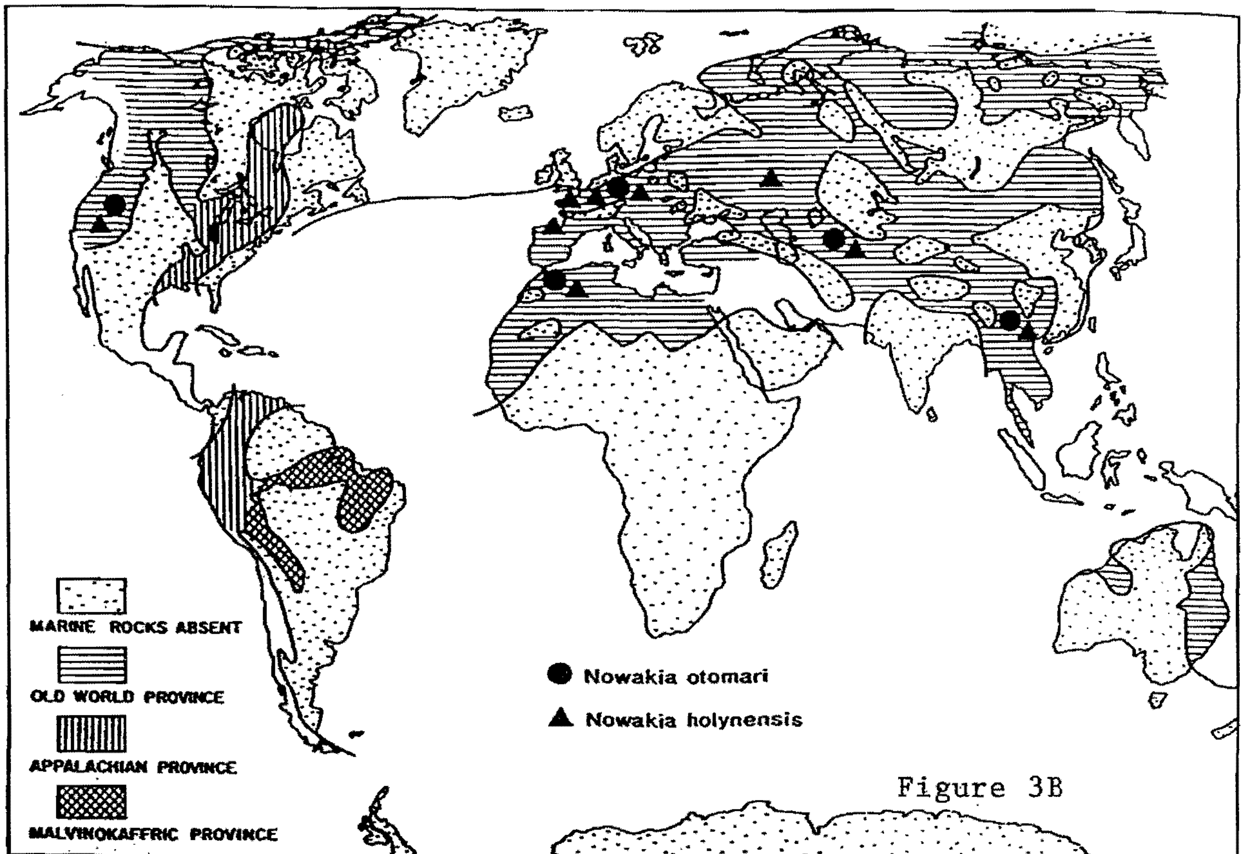


Figure 3B

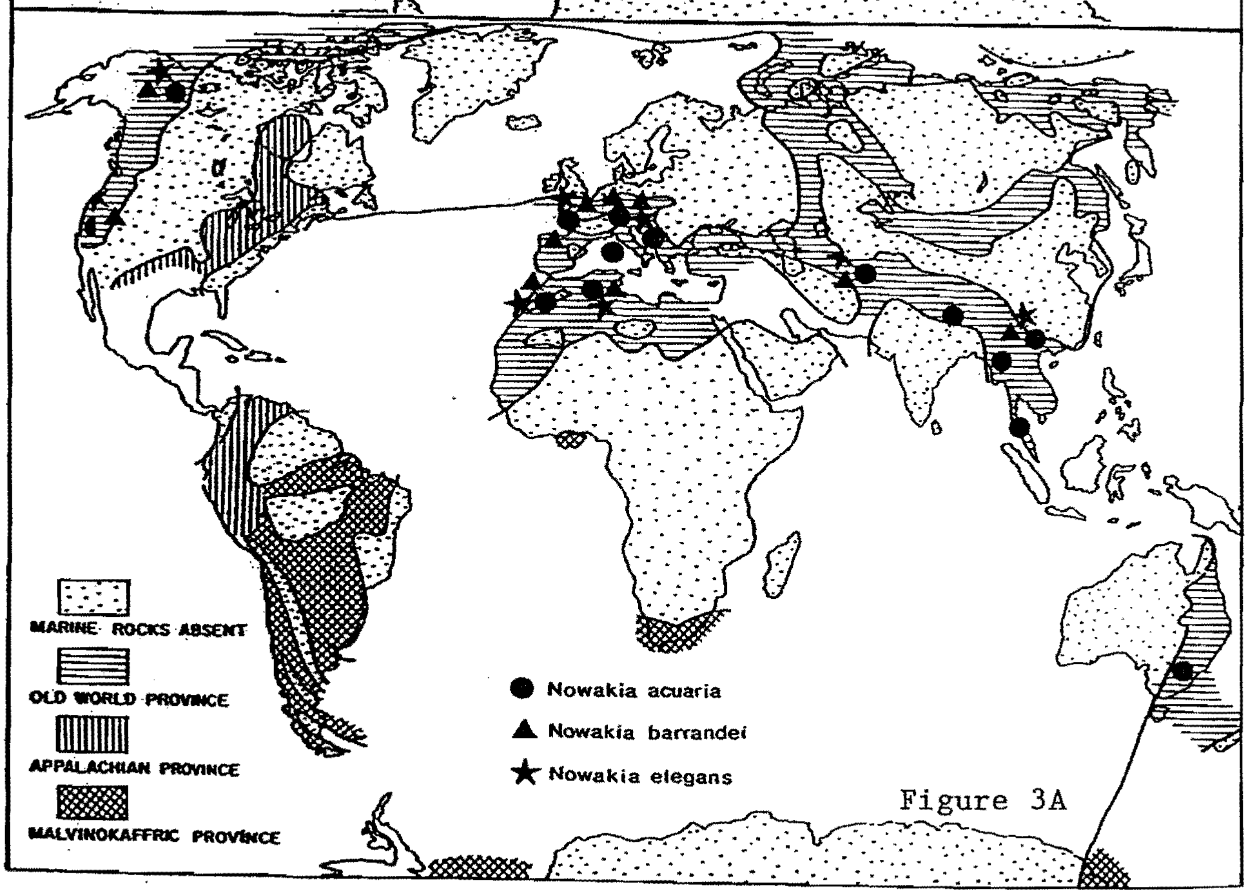


Figure 3A

advantages of using these beds as member-contact diagnostics in place of the traditional lowermost occurrence of dark colored chert. They subsequently reported that these "black beds" are continuous into the Selensgrove Limestone of central Pennsylvania and into the Onondaga Limestone of the central Hudson Valley of eastern New York (Ver Straeten and Brett, 1995). Based upon direct field observations in Europe and North Africa, these "black beds" are now regarded to represent the Chotec Event in the northern Appalachian Basin (C. Ver Straeten and E. Schindler, pers. com. 2002). This lends further support to the placement of the base of the Eifelian Stage at the contact of the Edgecliff and Nedrow Members of the Onondaga Formation.

The Upper Eifelian Kacak Event(s)

The GSSP for the base of the Givetian Stage is in Morocco at the first occurrence of *Polygnathus heminasatus*, a conodont which is unknown in eastern North America (Walliser et al., 1995) and which Sparling (1999) regards to be of dubious taxonomic integrity. Within the stratotype interval, the GSSP lies less than one half of a meter above a bed of black shale, which records the acme of the *otomari* Event (Walliser et al., 1995). Although this bioevent has been know by several names, most commonly Kacak-*otomari,* and variously diagnosed (see Truyols-Massoni et al., 1985), it is generally characterized as an interval of black shale that was deposited during a short term eustatic sea level highstand (House, 1985) and is recognized by the occurrence of the dacryoconarid *Nowakia otomari*. Walliser (1995) divided the "event" into two phases, which he referred to as the Lower Kacak Event and Upper Kacak Event. Referring to the T-R cycles of Johnson et al. (1985), Walliser (1995) placed the Upper Kacak Event (= acme of the *otomari* Event) immediately below the base of the Givetian and regarded both the Lower and the Upper Kacak Events to be correlative with the initial deepening phase of the T-R Cycle If. Differing in this opinion, Weddige (1998) regarded both of the Kacak events to lie within the T-R Cycle Ie and placed the base of the Givetian at the Ie-If boundary. If this proves to be an accurate determination, the base of the Gevetian Stage approximates the contact between the Oatka Creek Formation and the succeeding Skaneateles Formation.

DACRYOCONARID CLASSIFICATION AND SUCCESSION

Eaton (1832) described *Echinus gyracanthus*, a presumed sea urchin spine, from the "Corniferous Limerock" of eastern New York. Vanuxem (1842), Mather (1843), and Hall (1843) illustrated *Tentaculites ornatus* Sowerby from what is now known as the Lower Devonian Manlius Limestone of eastern and central New York. Rejecting the identification of this species by Vanuxem and Mather, and neglecting to mention his own previous illustration of the taxon, Hall (1859) described *T. irregularis* n. sp. and referred all tentacultids from the Manlius to this species. In couched and physically hidden language (see Lindemann and Melycher, 1997), Hall (1861) subsequently transferred his new species to *T. gyracanthus* (Eaton). Lindemann and Melycher (1997) redescribed *T. gyracanthus* (Eaton) and described *T. simmondsi* n. sp., the first new tentaculitid to come from the Devonian of New York since the days of James Hall.

Hall (1843, p. 173, text fig. 68.2) described *Tentaculites scalaris* Schlotheim and figured a specimen collected at Le Roy, NY. Hall (1877, Pl. 26, figs. 3-4) transferred *T. scalaris* to a new species *T. scalariformis* and illustrated a specimen from the "Upper Helderberg group" (= Onondaga Limestone) at Le Roy, NY. He also illustrated a new species *T. sicula* the syntypes of which were collected from "the Upper Helderberg (= Delaware) limestone at Delaware, Ohio (Hall, 1877, pl. 26, figs. 5-11). Hall (1877) is a quintessential James Hall publication, the origin of which is discussed by Oliver (1987). Hall (1879) placed *T. sicula* in synonymy with the earlier described *T. scalariformis,* refigured the species with one specimen from the "cherty (= Onondaga) limestone" at Le Roy, NY (pl. 31., figs 3-4) and, citing both superior abundance and quality of preservation, also refigured the species with specimens from Delaware, Ohio (Pl. 31, figs. 5-11). Hall (1888, pl. 64, fig. 20) again refigured specimens of *T. scalariformis* on a slab of "Corniferous (= Delaware) limestone" from Delaware, Ohio. In Ohio this species is now known to be abundant and widely distributed within both the Columbus and Delaware Limestones (Stauffer, 1909; Westgate, 1926). There have been few reports of this species from the Devonian of New York (Grabau, 1906; Oliver, 1954, 1956) where its range has not been extended since the days of James Hall.

Figure 3. Selected faunal elements of the four dacryoconarid events. A. *Styliolina*; B, *Striatostyliolina*; C, *Viriatellina*; D, *Nowakia*; E, *Costulatostyliolina*; F, *Tentaculites scalariformis*; G, inarticulate brachiopod; H, scolecodonts. Not to scale.

Hall (1843) also described *Tentaculites fissurella* n. sp. from the "Marcellus shale" and the Genesee slate" of central and western New York. Hall (1876, Pl. 31A, figs. 12-14) illustrated three specimens of this species and then refigured these same three as the types of a new species, *T. gracilistriatus*. Referring specimens with transverse sculpture to this new species, Hall (1879, Pl. 31A, figs. 1-34) transferred the more-or-less smooth forms to *Styliola fissurella*. At that time both *Tentaculites* and *Styliola* were regarded to be pteropods. Karpinsky (1884) proposed the new genus *Styliolina* in order to distinguish small conical fossils of the Paleozoic from the pteropod gastropods and transferred Hall's species to *Styliolina fissurella* (Hall). Lindemann and Yochelson (1994) redescribed this species, as well as the genus' type *S. nucleata* (Karpinsky), in order to dispel erroneous interpretations of the genus that had persisted throughout the second half of the 20th Century. Lindemann and Yochelson (1992) also redescribed *Tentaculites gyracanthus*, transferred the species to *Viriatellina gyracanthus* (Hall), and described *V. porteri* n. sp., the first new dacryoconarid to be described from the Devonian of New York since the days of James Hall.

What then is a dacryoconarid? The examples cited above are given, in part, to point out that here has been, and continues to be, a good deal of activity in the areas of classification and taxonomy of the tentaculitids their morphologic allies. Because this group has been virtually ignored in North America since the time of James Hall, most of this work has been undertaken by European paleontologists. The majority of these good people regard the dacs to be a monophyletic group with phylogenetic affinities to the tentaculitids and ally them with the Phylum Mollusca. However, this is not a universally held opinion (see Yochelson and Lindemann, 1986), and its further consideration lies beyond the biostratigraphic purposes of this report.

Paleozoic fossils that share the common characteristics of being small and conical have been in the literature since the early 1800s. They have been variously regarded to be echinoderm spines, brachiopod spines, small cephalopods, pteropod gastropods, or worms (see Yochelson and Lindemann, 1986). Detailed systematic attempts to develop a classification of the tentaculitids and to separate morphologially divergent forms date to the work of the Russian micropaleontologist Lyashenko during the 1950s. See Fisher (1962) or Boucek (1964) for citations to Lyasheko's plethora of publications. Fisher (1962) proposed a classification that further distanced the tentaculitids from divergent forms such as the hyoliths, cornulitids, and coleolids. Fisher (1962, p. W102) proposed the Class Cricoconarida to include the "small, narrow, straight, ringed true cones." He divided the class on the criterion of the morphology of the cone's embryonic chamber. Thus, the proposed Order Tentaculitida includes cricoconarids with a pointed conical embryonic chamber, and the Order Dacryoconarida includes those with a rounder or bulb-like embryonic chamber. The apical terminus of the dacryoconarid embryonic part may possess a small node or spine. The original description of the Order Dacryoconarida (Fisher, 1962, p. W114) is - "Small cricoconarids with pronounced teardrop-like embryonic bulb, which may have tiny apical spine emanating from it. Growth angle relatively greater in Tentaculitida. Exterior smooth or covered by broad ripple-like rings with rounded crest and troughs. Longitudinal ornamentation usually present. Juvenile portion smooth or with weakly developed rings. Shell wall thick or thin: no radial canals observed. Interior wall surface smooth or ringed. No evidence of septa though Novak reported a septum between the embryonic chamber and the rest of the interior. *M.Sil.(Wenlock.)-U.Dev.(L.Famenn.).*" The essence of Fisher's classification that pertains to this report appears below.

Class Cricoconarida Fisher, 1962
- **Order Tentaculitidae** Lyashenko, 1955
  - **Family Tentaculitidae** Walcott, 1886
  - **Family Homoctenidae** Lyashenko 1955
  - **Family Uniconidae** Lyashenko 1955
- **Order Dacryoconarida** Fisher, 1962
  - **Family Styliolinidae** "Grabau 1912"
  - **Family Nowakiidae** Boucek and Prantl, 1960

Boucek (1964) proposed a classification of the tentaculitids and their allies that preserved some aspects of Lyasheko and Fisher's (1962) work and added some of his own. Lardeux (1969) described several new taxa including the genus *Costulatostyliolina*. Since that time both "super" and 'sub" prefixes have abounded throughout the taxonomic hierarchy of the tentaculitids, producing a truly impressive set of categories. Fairly recent examples of this work may be found in Alberti (1993) and Farsan (1994). The outline, which appears below, retains the overall framework of Boucek (1964) with the addition of selected new taxa that have been assigned to the Order Dacryoconarida. It is not intended to even come close to being comprehensive, but rather is presented only to show the taxonomic locations of the dac genera that are discussed in this report. Descriptions of dacryoconarid genera, which follow, are not formal but are sufficiently diagnostic to facilitate their identification.

Class Tentaculitida Boucek, 1964
- **Order Tentaculitida** Lyashenko, 1955
  - **Family Tentaculitidae** Walcott, 1886
    - *Tentaculites* Schlotheim, 1820
  - **Family Uniconidae** Lyashenko, 1955
- **Order Homoctenida** Boucek, 1964
  - **Family Homoctenidae** Lyashenko, 1955
    - *Homoctenus* Lyashenko, 1955
- **Order Dacryoconarida** Fisher, 1962
  - **Family Nowakiidae** Boucek and Prantl, 1960
    - *Nowakia* Guerich, 1896
    - *Viraitellina* Boucek, 1964
  - **Family Styliolinidae** Grabau and Shimer, 1910
    - *Styliolina* Karpinsky, 1884
  - **Family Striatostylioinidae** Boucek, 1964
    - *Striatostyliolina* Boucek and Prantl, 1961
    - *Costulatostyliolina* Lardeux, 1969

The genus *Styliolina* (Fig. 2A) stands apart from other dacs in that the shell consists of a single, 10 micron thick, layer of homogenous calcite and lacks exterior sculpture with the exception of weak, longitudinal striae. Previous reports of the absence of striae on the surface of *Styliolina* Karpinsky are erroneous (Lindemann and Yochelson, 1994). *Styliolina fissurella* (Hall) is the only representative of the genus that is currently known from eastern North America. An undescribed species of the genus appears to be present in the argillaceous beds of the Nedrow Limestone as well as the Chestnut Street submember of the Bakoven Formation at CVNY., but it is not yet certain. The reported range zone of the *Styliolina* in New York extends from the upper Frasnian Angola Member of the West Falls Formation (Yochelson and Kirchgasser, 1986) down to the base of the Onondaga Formation (Lindemann and Yochelson, 1984). However, I can now report that *Styliolina* occurs in the Emsian the Bois Blanc Limestone of western New York, the lower Schoharie Formation at Kingston, New York, and in the Esopus Formation of central Pennsylvania. At this time, neither *Styliolina* nor *S. fissurella* (Hall) are of any practical use in biostratigraphic work.

Striatostyliolina (Fig. 2B) appears to differ from *Styliolina* primarily in the strength of the longitudinal striae in the surface of the shell. Specimens of *Striatostyliolina* are somewhat longer and more robust than most specimens of *Styliolina*, though this is hardly a diagnostic criterion. *Striatostyliolina* has not been reported formally from eastern North America and is currently know with certainty only from the indicated horizons of the Bakoven and Oatka Creek Formations (Fig. 1) in the vicinity of CVNY. This situation will soon change.

Nowakia (Fig. 2D) is recognized by the presence of sharp-crested transverse rings and longitudinal costae. Although the possible presence of *Nowakia* in Frasnian strata of western New York was mentioned by Yochelson and Kirchgasser (1986), the genus has not been formally reported from eastern North America. It is now know with certainty to be present in the Halihan Hill Bed of the Oatka Creek Formation throughout New York, as well as in the Bakoven Shale and upper Berne Member of the Oatka Creek Formation (Fig. 1) at CVNYwhere it appears that three or more species are present. With the possible exception of the Yochelson and Kirchgasser (1986) report, *Nowakia* is not curretly known to occur in any other New York strata .

Viriatellina (Fig. 2C) differs from *Nowakia* only in the shape of the transverse rings. Those of *Viriatellina* are more rounded and often more subtle than those of *Nowakia*. Comparison of illustrated type specimens of species, variously referred to these two genera, shows that there is a disconcertingly large overlap of ring morphologies. Furthermore, mechanical compaction of specimens often obscures the presence of weak rings and corrasion of the shell surface may obliterate longitudinal costae, taphonomically transforming a *Viriatellina* into a *Styliolina* or a *Costulatostyliolina* mimic.

Tentaculites gracilistratus appears in the faunal lists for many Hamilton Group formations throughout eastern North America. Although many of these are accurate reports of *Viriatellina* *gracilitstriata* (Hall), it is now certain that several undescribed species are currently referred to this taxon. The base of the *V. gracilistriata* (Hall) range zone is understood to be in the Union Springs Shale. The*Viriatellina* that occurs in the Nedrow Limestone (Fig. 1) is an undescribed species, which was first reported, though misidentified as *Nowakia*, by Lindemann and Yochelson (1984). Although the known first occurrence of *Viriatellina* in New York is at the base of the Nedrow, specimens that may be referred to the genus have been observed in acetate peels from a sample of Esopus Shale that was collected by C. Ver Straeten in central Pennsylvania.

Boucek's (1964) description of *Metastyliolina* specifies a long, slender dacryoconarid with weak transverse sculpture, numerous longitudinal costae, and a very small, pointy embryonic chamber. Larduex (1979) described the new genus *Costulatosytliolina* (Fig. 2E) to accommodate dacryoconarids that are similar to *Metastyliolina* but possess relatively few, strong costae and a well-developed, rounded embryonic chamber, with or without an small apical node. Hall (1879 p. 180) described several varieties of *Styliolina fissurella* including *S. fissurella strigata*, which he reported from "the Marcellus shale and in limestone concretions in the shale...at Cherry Valley," New York. He figured two specimens, one of which is a *Viriatellina* and the other a *Costulatostyliolina*. The latter is to be the type specimen of *Costulatostyliolina strigata* (Hall), the first species of this genus to be reported from the Devonian of New York (Lindemann, 200?, in prep.). At present, the *Costulatostyliolina* range zone in New York extends only from the concretionary interval of the Bakoven Shale to the Chestnut Street submember of the Hurley Member of the Union Springs Formation (Fig. 1).

DACRYOCONARID BIOEVENTS

Not all bioevents are created equal in that they result from environmental perturbations of many kinds and magnitudes. Daily and annual solar cycles are recorded in the tree rings and the growth lines of brachiopod shells and coral epithecae. The occasional hurricane or tsunami may be recorded as coquinite layer. The first and last occurrences of a given species record a biotic response to some sort of environmental forcing mechanism. Bioevents become more interesting when they are recorded in relatively thin stratal intervals that are lithologically distince and paleontologically unique. These event strata have disconformible bases and are laterally continuous on the regional to global scales. Many such strata are now understood to result from eustatic sea level high stands of geologically brief duration. These flooding events often weakened or totally breached land barriers that had previously existed between ocean basins thereby enabling the geologically instantaneous mixing of formerly isolated marine faunas. Migrants into an ocean basin could potentially colonize their new habitats at about the same rate that the zebra mussel has recently spread throughout he fresh water ecosystems of North America. Migratory, extinctive, and evolutionary faunas preserved in strata that were deposited during these times of profound global change are among the most interesting and biostratigraphically useful of all bioevents. Whereas the K/T asteroid impact captures the imagination, comparable events appear to have been too few and far between to be of much use in chronostratigraphic work.

Prior to presenting the four dacryoconarid bioevents that are currently known at CVNY, it is instructive to establish the biogeographic context of Early and Middle Devonian Earth. Throughout that time interval the global marine environment consisted of three major biogeographic units known as the Old World Realm (OWR), the Eastern Americas (= Appalachian) Realm (EAR), and the Malvinokafferic Realm (MR) as shown in Figure 3. For present purposes it is unproductive to quibble over the terms "province" and "realm." Lutke (1985) and McGhee (1997) respectively discuss the distribution of dacryoconarid and brachiopod taxa in Lower and Middle Devonian strata. They, and the authors cited by them, make clear the case that Early Devonian faunas were initially extremely endemic and became increasingly cosmopolitan over time (Fig. 3A, 3B). Decreased endemism was predominately result of the migration of OWR taxa into the EAR. Lutke (1985) regarded the endemic OWR dacryoconarids to have been tropical organisms, barred from the EAR by water temperature. Lindemann (1996) reported that the first occurrences of genera in the Middle Devonian of New York invariably involve OWR genera, but not species, that migrated into the Appalachian Basin during marine transgressions. The migrations were intermittent, temporally corresponding to eustatic high stands that facilitated both physical accessibility and the occasional warming of the EAR waters. Speciation may have occurred during migration as an adaptation to the indigenous faunas and cooler environments of the EAR. Although it is entirely arm waving speculation at this time, I would suggest that the enigmatic appearances, disappearances, and reappearances of dacs in the Hamilton Group may have been thermally driven.

Dacryoconarid Event I

This bioevent is characterized by the association of *Tentaculites scalariformis* (Fig 2F), *Styliolina, Viriatellina,* tasmanitids, scolecodonts (Fig. 2H), the inarticulate brachiopod *Craniops*? (Fig. 2G), and a diversity of ostracodes. Berdan (1981) lists eighteen ostracode genera as being in the Nedrow and Moorehouse Limestones, many of which became extinct during deposition of the Onondaga Formation. The ichnogenera *Chondrites* , and *Thallasinoides* are also frequently present. The Event I assemblage first occurs at the base of the Nedrow Limestone throughout much of the state. It is recorded in to two argillaceous intervals of the Nedrow at CVNY (Fig. 1) and in at least five argillaceous intervals within the Nedrow of central and western New York. In all known occurrences, the Event I fauna is restricted to the stratigraphic interval between the base of the Nedrow and the two "black beds" at the top of the member (Ver Straeten and Brett, 1995). Although the "black beds" have not been positively identified at CVNY, they may be represented by two argillaceous beds in the lowermost Moorehouse Limestone. In east-central and eastern New York, the lithologies of the upper Nedrow and lower Moorehouse differ from those of the central New York type sections, and the Nedrow-Moorehouse contact is arbitrarily placed at the first occurrence of dark colored chert.

The base of the Nedrow is regarded to be a synchronous event horizon (Oliver, 1954, 1956; Rickard, 1975, 1981) deposited during a eustatic deepening event (Brett and Ver Straeten, 1994). The argillaceous intervals of Dacryoconarid Event I represent the transgressive pulses of parasequence-scale stragigraphic sequences. They culminate in the "black beds," which are regarded by C. Ver Straeten and E. Schindler (pers. com., 2002) to be correlative with the lower Eifelian Chotec Event. The first occurrence of *Polygnathus costatus costatus* 2.3 m above the base of the Nedrow at CVNY constrains the base of the Eifelian to a position somewhat lower than this horizon. Thus, Dacryoconarid Event I is in the lowermost Eifelian, and the base of the interval within which this event fauna is preserved, the base of the Nedrow Limestone, may well be correlative with the base of the Eifelian Stage and the Middle Devonian Series. Currently undescribed species of *Styliolina* and *Viriatellina,* which first occur at the base the Nedrow, have the potential to serve as proxy indexes of the Emsian-Eifelian boundary within the Appalachian Basin. Although it is tempting to suggest that the first occurrence of *Tentaculites scalariformis* may also serve as an index to the base of the Eifelian, it has been reported from the Emsian Springvale Sandstone (= basal Bois Blanc Limestone) of Ontario (Stauffer, 1915). The accuracy of that report must be assessed before further statements regarding the chronostratigraphic utility of the first occurrence of *T. scalariformis* can be made with certainty.

Dacryoconarid Event II

This bioevent is simply the first (lowermost) occurrence of *Striatostyliolina* (Fig. 1). It is coincident with the base of the Bakoven Member of the Union Springs Formation. This is the first report of *Striatostyliolina* from the Devonian of the Appalachian Basin, other than passing references to the taxon (Lindemann, 1996; Robinson and Lindemann, 1997). The Onondaga-Union Springs contact is an unconformible horizon that represents the marine deepening event of T-R Cycle Id (Johnson et al., 1985) and Depositional Sequence 4 of Ver Straeten and Brett (1995).

Dacryoconarid Event III

This bioevent is a dacryoconarid epibole characterized by the association of *Styliolina, Viriatellina, Striatostyliolina, Costulatostyliolina,* and *Nowakia.* It is restricted to the concretionary interval of the Bakoven Shale and to the Chestnut Street submember of the Hurley Member (Fig. 1). Within the Bakoven, the dac fauna is preserved only in the concretions, which are of early diagenetic origin (Dix and Mullins, 1987; Lindemann and Schuele, 1996), and not in the shale proper. Preservation is excellent in the Chestnut Street bed(s). As is the case with *Striatostylioina,* this is the first report of *Costulatostyliolina* from the Devonian of the Appalachian Basin. *Costualtostyliolina* is restricted to the Event III interval. The first (= lowermost) occurrence of *Nowakia* is also at the base of this interval. This genus appears to have emigrated from the region following Event III only to return during Event IV. *Costulatostyliolina,* on the other hand, appears to have emigrated from the region following Event III, never to return.

Dacryoconarid Event IV

This event is characterized by the presence of *Styliolina* and *Nowakia*. *Viriatellina* is present only in the lower beds of the interval (Fig. 1). At CVNY this interval occupies a section of the Berne Mmeber of the Oatka Creek Formtion that extends from 23-34 m above the top of the Cherry Valley Limestone. One of the undescribed species of *Nowakia* within this interval has also been observed in the Halihan Hill Bed that marks the base of the Chittenango and Otsego Members of the Oatka Creek and Mount Marion Formations throughout the state (Baird et al., 1999). *Nowakia* is not known from the Hamilton Group above the Event IV interval.

The Kacak-*otomari* Event has long been regarded to be correlative with some part of the Chittenango Shale (Truylos-Massoni et al., 1990). The location of the precise stratigraphic interval of the event is of biostragraphic interest because the acme of the event (= Upper Kacak Event of Walliser, 1995) lies in very close proximity to the base of the Givetian Stage (Ziegler and Klapper, 1985). Ver Straeten and Brett (1996) reported that the Union Springs and Oatka Creek Formations lie within the Kacak-*otomari* interval and implied that the latter may correspond to the acme of the event. Robinson and Lindemann (1997) concurred in part, but regarded the Chittenango (= Oatka Creek) Shale to be correlative with the Lower Kacak Event. This was based on an ignorance of the presence of *Nowakia* in the Bakoven Shale and the understanding that the Upper Kacak Event was correlative with the eustatic high stand of T-R Cycle If. Now that *Nowakia* is known to occur in the Bakoven the Upper Kacak Event, which has been correlated to the uppermost part to the T-R Cycle Ie high stand, the determination of Robinson and Lindemann (1997) requires modification. Accordingly, I now regard Dacryoconarid Event III to be correlative with the Lower Kacak Event and Dacryoconarid Event IV to be correlative with the Upper Kacak Event. That said, it must be noted that *Nowakia otomari* itself remains unknown in the New York section despite a diligent search for it. At present, I can only assume that this species was ecologically barred from migration into the Eastern Americas Realm but the genus was not. With the exception of *Styliolina fissurella*, it does not appear that Old World species were adapted to the Eastern Americas environment.

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ROAD LOG

This road log begins at Exit 15 of US I87, the Adirondack Northway. Readers will not fail to note that the road log is in whole-mile increments. The odometer on my 1993 Toyota pickup does not record tenths of miles. That option came only with a touring package, which was excessively costly.

Mileage

0 Take the Saratoga Springs Exit 15 of US I87 west on to NY Rt. 50. Locally, this road has been named the C.V. Whitney Memorial Highway. US Rt. 9 enters from the right (north) at the second traffic light. Continue straight in the right hand lane on the combined Rts. 50 and 9 to Broadway in Saratoga Springs.

1 Cross Broadway continuing straight ahead (west) on to Van Dam Street. Rts. 50 and 9 turn left at Broadway, we do not. NY Rt. 9N enters from a diagonal left. Continue straight on what is now Rt. 9N north past the Saratoga Hospital and the Stewart's ice cream plant into the Town of Greenfield. The ice cream plant is the type locality of Stewart's Shops everywhere.

4 Turn left on to Saratoga County Rt. 21, Middle Grove Road. The upcoming turn is indicated by a blue Kilmer's Lumber sign and a roadcut in the Upper Cambrian Galway Formation on the right side of 9N. If you cross under the railroad overpass, you have missed the turn. FYI: The first left from Middle Grove Road leads to Lester Park, the type locality of the Upper Cambrina Hoyt Limestone and its world famous *Cryptozoon* stromatolite reefs. Continue stratight on Middle Grove Road until it terminates at the intersection with NY Rt. 29.

12 Turn right (west) on to Rt. 29 and continue to Rt. 30A at Johnstown. DO NOT turn on to Rt. 30 toward Amsterdam at Broadalbin.

32 Turn left (south) on to Rt. 30A at Johnstown and descend into the Mohawk Valley.

37 Turn right (west) on to Rt. 5 at Fonda.

48 At the traffic light intersection with Rt. 10 in Palatine Bridge, turn right uphill for a brief rest stop at a popular purveyor of fast food. There will not be another "official" rest stop for some time to come. Follow Rt. 10 through Canajoharie to Sharon Springs.

59 Turn right (west) on to Rt. 20, the Cherry Valley Turnpike, at Sharon Springs.

64 Pull off of Rt. 20 to the right into a state parking area. Here we will regroup and review the overall stratigraphic setting of Cherry Valley. Exit the parking area and continue west on to Rt. 20. Descend into Cherry Valley through a long road cut and ascend the west side through a road cut in the Onondaga Limestone.

76 Pull on to and right shoulder of the road just beyond a large road sign above the top of the road cut. Walk down hill to the baseof the roadcut.

STOP 1. DACRYOCONARID EVENT I. The base of this outcrop is in the upper Carlisle Center, which is characterized by the ichnofossil *Zoophycos.* The sub-Onondaga disconformtiy is marked by abundant phosphate nodules at the Edgecliff-Carlisle Center contact. Much of the Onondaga Formation's Edgecliff Member is a massive to thick-bedded, coraliferous limestone. The upper Edgecliff contains nodules of light-gray chert and the top of the member is easliy recognized the red staining of oxidized pyrite nodules. The base of the Dacryoconarid Event I interval is coincident with the Edgecliff-Nedrow disconformity, which is at the contact of this pyriteiferous Edgecliff bed and base of the lowermost argillaceous Nedrow bed. The base of the Nedrow is also the base of the *Viriatellina* and *Tentaculites scalariformis* local range zones. At this locality, the fauna of Dacryoconarid Event I appears to be restricted to the two argillaceous intervals of the Nedrow. The top of this interval corresponds to the top of the *T. scalariformis* local range zone, and to the uppermost known occurrence of *Viriatellina* in the Onondaga Formation.

The arbitrarily chosen Nedrow-Moorehouse contact is the bed of limestone that contains the lowermost occurrence of dark-gray chert nodules. Immediately above this horizon, there are two argillaceous intervals, which may be correlative with the two uppermost Nedrow "black beds" of central New York. If this correlation proves to be correct, strata referred to the lower Moorehouse at this locality are correlative with the upper Nedrow of central New York and with the Chotec Event. In any case, the base of the Dacryoconarid Event I interval is either at, or in proximity to, the base of the Eifelian Stage.

Drive uphill a short distance and park in the highway department staging area. The Cherry Valley Member and the lower beds of the Berne Member of the Oatka Creek Formation are exposed in the road cut immediately above the staging area. As it is more convenient to examine and collect from this interval here than it is at Stop 3, we will do so.

At end of stop, turn back (east) on Route 20. Drive in the right hand lane and decelerate immediately after passing beneath the old railroad overpass. If the fates have been kind, there will be large talus blocks of the of the Carlisle Center, which may afford excellent bedding plane exposures of *Zoophycos.* If this is the case, we will stop briefly for photographs. Please do not damage, or collect from, these large blocks. There are plenty of small blocks to be had that do not require the use of a hammer.

Continue east on Rt. 20.

77 Park on the shoulder of Rt. 20 adjacent to a 2+ m thick outcrop of massive limestone.

STOP 2. DACRYOCONARID EVENT II

The 2 m exposure of massive grainstone and packstone on the south side of Rt 20 is the easternmost exposure of the Seneca Limestone. The Tioga B Bentonite occurs in the reentrant at the base of the exposure. The low exposure of packstone on the north side of Rt. 20 is in the uppermost Moorehouse. At this locality, both members were deposited toward the culmination of a regressive phase, the beginning of which is recorded in the Moorehouse at Stop 1. The top of the Seneca is an erosional truncation surface. At other localities in central and eastern New York, this surface is a classic Devonian bone bed.

The base of the Bakoven Shale is not exposed here, though it has been excavated in a stream gully within sight of this outcrop and is (sometimes) exposed nearby at Optional Stop A. The Bakoven was deposited during a eustatic flooding phase which appears to have breached the transcontinental arch, permitting the immigration of dacs from the equatorial Old World Realm, of what is now Arctic Canada, into the Eastern Americas Realm. *Striatostyliolina* was the first new dac to access the northern Appalachian Basin during this highstand. Its first occurrence is coincident with the base of the Bakoven Shale and is the diagnostic of Dacryoconarid Event II

At the end of stop, continue east on Rt. 20 and take the first right hand turn onto Chestnut Street. Park on the wide shoulder, well off of the pavement.

STOP 3. DACRYOCONARID EVENTS III AND IV.

The base of the Chestnut Street road cut is in the upper concretionary part of the Bakoven Shale. The upper part of the outcrop, which is visible from the road, is in the Berne Member of Oatka Creek Formation. The massive limestone bed between them is the Cherry Valley (Fig. 1). The Cherry Valley immediately overlies a centimeter-scale bed of shale, which overlies a 10-25 cm bed of limestone. These are the Lincoln Park and Chestnut Street submembers of the Union Springs' Hurley Member. Dacryoconarid Event III, which is not regarded to be correlative with the Lower Kacak Event of Walliser (1995), occupies the concretionary interval of the Bakoven and the Chestnut Street bed. This is the total know range zone of *Costulatostyliolina* (Fig. 1) in the northern Appalachian Basin. Similarly, *Nowakia* also first occurs in the Bakoven and is present in the Chestnut Street bed. *Nowakia* is absent from the section above this bed until it reappears in the Berne Member of the Oatka Creek Formation 23-34 m above the top of the Cherry Valley. This 11 m thick section of the Berne is interval of Dacryoconarid Event IV. It is now regarded to be correlative with the Upper Kacak Event of Walliser (1995). This part of the section can be accessed either by scrambing up through the very sooty lower Berne above the Cherry Valley or by following a path up hill beneath the power line that intersects the road just above where we turned off of Rt. 20. Intermittant outcrops are present along the south side to this path and the hill side immediately above it. The crest of the section along the powerline is in a fine-grained arenite that lies above the highest occurrence of *Nowakia*, which marks the top of the Dacryoconarid Event IV interval.

This is the final stop of the more formal part of this field trip. Depending on contingencies, we may quit at this point or continue on to Optional Stop A.

If you are returning directly to Lake George, follow the trip log in reverse from Sharon Springs, on to Rt. 10, to Canajoharie. Access the NYS Thurway, US Rt. I90, east at Canajoharie. Remain on the Thruway to Albany and exit on to the Adirondack Northway, US Rt. 87, north to Lake George.

To reach Optional Stop A, continue east on Rt. 20 about 5 miles beyond Sharon Springs to Sharon and turn right (south) toward Cobleskill on Rt. 145. The upper Onondaga Formation and lower Bakoven Shale are exposed in a ditch/ephemeral stream on the west side of the road. If the weather has been dry, it is possible to walk up through the uppermost limestone beds and locate the Onondaga-Bakoven contact. the lowermost shale bed is Daryoconarid Event I, the first occurrence of *Striatostyliolina*. Watch your trip leader carefully for the optimal place to pull on to the right shoulder of the road and park.

At the end of stop, continue south on Rt. 10 thorough Lawyersville and on to Cobleskill. Turn left (east) on to the combined Rts. 145 and 7. A brief visit to a purveyor of fast food is in order here to access the facilities and discuss options. If you are returning to Lake George, continue east on Rts. 145 and 7, and take US Rt. I88 east toward Schenectady. I88 ends at the New York State Thruway, Rt. I90, at Rotterdam. Take the Thruway east to Albany (this is a toll free section) to Albany and exit on to the Adirondack Northway, US I 87, north to Lake George.

Highlighted road maps will be distributed if we are to continue on to Optional Stop B. This stop is a road cut in the Union Springs Formation on Camp Pinnacle Road south of John Boyd Thatcher State Park and above the Helderberg escarpment. The top of the Onondaga Formation is exposed on the flats below the intersection of Beaverdam and Camp Pinnacle Roads. The Cherry Valley Limestone is present in the ditch uphill from the shale exposure. Only *Styliolina* and *Viriatellina* are present in the upper section of the Union Springs at this location. Although *Costulatostylioina* is not present, *Nowakia* is abundant in the lower, darker part of the section. The form of *Nowakia* *t*that occurrs in this interval is very similar to N. otomari, though it does not appear to be that species. None the less, this part of the outcrop is referred to the Dacryoconarid Event III interval and is regarded to be correlative with the Lower Kacak Event of Walliser (1995).

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