FOSSIL FAUNAS AND MICROSTRATIGRAPHY OF THE UPPER LUDLOWVILLE FORMATION: SMALL-SCALE SEA LEVEL FLUCTUATIONS AND CONVERGING UNCONFORMITIES

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INTRODUCTION

The Middle Devonian (uppermost Eifelian-Givetian) Hamilton Group of New York State has long been known for its abundance and diversity of well-preserved marine fossils. Sands and muds eroded from the Acadian Mountains that rose to the east (present directional sense) in response to the collision of Laurussia with Avalonia accumulated at the northern end of the Appalachian Foreland Basin, a northeast-trending trough that subsided as the crust isostatically adjusted to the weight of the growing mountain range. A steep siliciclastic-dominated slope descended westward from a nearshore sandy platform into the deep, axial part of the basin, which at the time passed through the present-day Finger Lakes region (Brett and Baird, 1990). Beyond that a western muddy carbonate shelf rose gently toward the shoaling Findlay-Algonquin Arch.

Western shelf sequences include intervals of gray to black mudrock punctuated by thin, laterally persistent bioclastic and diagenetically enhanced limestone beds and calcareous concretion horizons. The carbonate horizons were long known as widely-traceable marker beds; the intervening, seemingly monotonous mudrock intervals have only recently been shown to consist of distinct and widely traceable "depositional units." For example, Batt (1996) distinguished more than 190 depositional units comprising the 20.6 m thick Wanakah Shale Member (Ludlowville Formation) exposed along Rush Creek in Erie County.

Each depositional unit includes two major parts: a basal fossil-rich horizon ("shell bed") overlain by a relatively fossil-poor shale or mudstone. The basal part includes the remains of organisms that accumulated during periods of time (perhaps hundreds or thousands of years) when little if any mud was transported across the deep basin to this offshore shelf setting (Fig. 1). The overlying fossil-poor mudrock represents mud that had been re-suspended from nearshore areas and transported into the area during major storm events. The mud blanketed large areas of sea floor, burying accumulated remains and living communities to promote excellent fossil preservation. A given layer of storm-transported mud (mud tempestite of Brett et al., 1986) is an isochronous bed which, when considered with the underlying shell bed, may be correlated on the basis of lithology and fossil content. The widespread correlation of these depositional units allows the creation of a highly refined chronostratigraphic framework that facilitates the testing of various concepts of paleoecology and sequence stratigraphy on a regional and temporal basis.

The current investigation examines the fossil faunas and "microstratigraphy" of the upper part of the Ludlowville Formation of the Hamilton Group in western and west-central New York State.

Cyclic vertical (up-section) lithologic and faunal changes suggest that deposition was affected by sea level fluctuations of various magnitude. The upper part of this interval also contains several unconformities which may with detailed correlation be shown to merge westward into a single erosion surface separating what remains of the Ludlowville Formation from the overlying Moscow Formation.

STRATIGRAPHY OF THE STUDY INTERVAL

The upper part of the Ludlowville Formation includes the Wanakah Shale, Spafford Member, and Jaycox Member (Fig. 2). Grabau (1917) named the Wanakah Shale for an exposure of 20 m of medium gray shale with thin carbonate horizons at Wanakah Cliff along the Lake Erie shore in Erie County. The unit grades eastward into dark gray to black shales in the western Finger Lakes region (basin center). Further east, equivalent rocks belong to the silty Ivy Point Formation (Kloc, 1983).

Three meters of calcareous shale exposed in the Genesee Valley area, placed by Cooper (1930) in the overlying Tichenor Member of the Ludlowville Formation, were included by Grasso (1973) in the Wanakah Shale. Baird (1979), however, designated this interval as the Jaycox Member and placed the Tichenor Member in the overlying Moscow Formation by correlation with the Portland Point Member and the recognition of a regional sub-Tichenor unconformity that truncates successively older Ludlowville units when followed westward. The uppermost meter of the newly-refined Wanakah Shale at Jaycox Run, an interval of silty mudstone and shale immediately below the Jaycox Member, was then determined by Mayer et al. (1994) to represent the westernmost equivalent of the Spafford Member described in the Owasco and Skaneateles Lake valleys of central New York (Smith, 1935).

The Wanakah Shale as presently defined may be divided into four submembers (Fig. 2). Miller (1991) designated the highly fossiliferous lower 5 m of the unit, which due to its numerous diagenetically enhanced marker beds may readily be traced across western and central New York, as the Darien Center Submember. Batt (1996) used lithologic and faunal dominance trends to subdivide the remainder of the member into three additional but unnamed submembers. The lowest of these, here designated as the Idlewood Cliffs Submember, includes 8.5 m of dark gray to nearly black fossil-poor shale with widely spaced bundles of thin limestone bands at Idlewood Cliffs, along the Lake Erie shore within 0.5 km north of the mouth of Eighteenmile Creek (Town of Hamburg, Erie County). The overlying Highland-On-The-Lake Submember, named here for exposures along the Lake Erie shore 0.5 to 1 km south of the mouth of Eighteenmile Creek (Town of Evans, Erie County), includes 5 m of dark gray shale with bundled concretion horizons. The remainder of the Wanakah Shale includes fossiliferous gray shales and is here designated as the Buffalo Creek Submember for exposures along Buffalo Creek at Bullis Road in the Town of Elma, Erie County. There the submember is 3.25 m thick and includes all of the marker beds contained in the interval in the shallower western shelf setting as well as key beds that mark the top of the submember from Buffalo Creek eastward but were erosionally removed from western sections.

The study interval in the present investigation (uppermost Highland-On-The-Lake Submember through Jaycox Member) contains numerous marker beds (Fig. 2), most of which actually include several depositional units. Some marker beds were originally named by Grabau (1898-99) for dominant fossils, but most have been re-named after type localities. The bundle of concretion horizons marking the top of the Highland-On-The-Lake Submember is Kloc's (1983) Spring Brook Interval (Grabau's "Upper *Athyris spiriferoides* bed"). The lower part of the Buffalo Creek Submember

contains a thin dark gray shale interval with abundant styliolinids and (in western sections) a prominent horizon of calcareous concretions. This interval, which includes Grabau's "Tentaculite Bed," is here designated as the Milestrip Road Bed for an exposure immediately north of where that road crosses Smoke Creek in the Town of Orchard Park. The most highly fossiliferous part of the Buffalo Creek Submember, locally containing limey lenses or concretion horizons, was designated as the Blasdell Bed by Kloc (1983). The lower part of this interval includes Grabau's "*Demissa* Bed" and "*Stictopora* Limestone" in western sections. The Bloomer Creek and Romulus beds mark the top of the submember in eastern sections (Baird, 1981). Mayer (1989) designated a medium gray fossiliferous silty mudstone at the base of the Spafford Member as the Limerick Road Bed. The base of the Jaycox Member, ranging from limestone in western sections to calcareous siltstone in the Finger Lakes region, was named the Hills Gulch Bed by Kloc (1983). The Jaycox Member also includes two prominent coral-rich horizons, the Greens Landing Coral Bed and the Cottage City Coral Bed (Mayer, 1989).

METHODS

The study interval was measured and sampled at nine sections spaced along the Ludlowville Formation outcrop belt (Fig. 3), spanning a distance of more than 140 km. The entire Wanakah Shale was examined in five closely-spaced sections in Erie County by Batt (1994), but only the trilobite beds interval of the Darien Center Submember (Batt, 1995) and the Rush Creek section (Batt, 1996) have been discussed in publication. The addition of the four eastern sections extends the line of transect from the western shelf into the foreland basin, and the addition of the Spafford and Jaycox members completes the study interval.

Centimeter-scale measurement and description of each section revealed that the study interval everywhere consists of distinct depositional units. The relatively close spacing of the sections facilitated detailed correlation of these beds along the length of the transect in spite of basinward facies changes (Figs. 4-7). Basinward thinning and decrease in resolution in some intervals appear to reflect a number of factors including the increasing rarity of recognizable shell beds in deeper, less oxygenated settings, restriction of significant diagenetic enhancement to shallower parts of the western shelf, and decreased sediment influx into the deeper basin.

All sections were sampled for fossils, with at least 300 specimens collected from each depositional unit. The number of specimens of each macrofossil species was recorded for every sample, and after adjusting for disarticulated remains relative abundances were calculated (it should be noted that while crinoid remains were noted, they were not included in the counts due to their highly disarticulated nature).

Miller (1986) noted that the fauna contained in any given bed (depositional unit) actually represents a "time-averaged fauna," an assemblage averaged over perhaps hundreds of years as skeletal debris accumulated on the sea floor before storm-related burial. Even so, the relative abundances of the faunal components do reflect overall (averaged) environmental conditions during a given bed's history, conditions which may have been significantly different from the conditions under which the overlying bed was deposited perhaps a thousand years later. Thus bed-to-bed changes in faunal dominance may reflect changes in environmental parameters such as general water depth, turbidity, and oxygenation through time at a given locality.

For each sample, species with similar life habits and general environmental tolerances (depth, turbidity) were assigned to faunal categories. The data were then plotted on faunal frequency diagrams to illustrate up-section changes in the relative abundances of these categories which are interpreted to reflect changes in environmental conditions through time. Figures 8-13 are examples of faunal frequency diagrams constructed for the study interval at some of the sections discussed in the text.

These diagrams, introduced by Batt (1995) in an investigation of the trilobite beds of the Darien Center Submember, are a modification of a cumulative frequency graph developed by Bandy (1953) to interpret dominance trends for foraminifera. Percent abundance is indicated along the horizontal axis while beds are numbered from the bottom upward along the vertical axis (see Figs. 8-13). Each bed is represented by a single horizontal line (not drawn) rather than an interval of proportional thickness, because the fauna within a recognized bed is a time-averaged association and individual bed thickness is therefore insignificant. The space between the bed lines in essence represents the contact between synjacent beds in the outcrop (zero thickness). This in reality more closely reflects the relative time represented by beds and contacts. Brett et al. (1990) suggested that chemical and biological destruction of skeletal material on the sea floor would result in loss of identifiable remains of all but the last few generations of a fauna living prior to burial by storm-transported mud. During the non-represented times (between major storm-events), faunal associations changed in response to changing conditions (such as depth and/or turbidity). The changing widths of faunal categories from bed to bed thus represent the net changes in dominance between preserved time-averaged faunas.

In the present investigation, the faunal categories shown on these diagrams are arranged with those believed to be most characteristic of shallower bottoms to the left and deeper bottoms to the right. Also, since at any given depth different turbidity levels may affect the fauna represented (see Brett et al., 1990 for a discussion), categories representing higher turbidity are placed to the left of those representing lower turbidity.

DISCUSSION

The Spring Brook Interval (beds H1-H3) at the top of the Highland-On-The-Lake Submember includes numerous horizons of calcareous concretions in western (shallower) sections (Fig. 4) where sufficient calcareous debris was available to promote diagenetic enhancement. The fauna in this and synjacent intervals is dominated by the diminutive spiriferid brachiopod *Ambocoelia umbonata* (Figs. 8-11), characteristic of relatively clear (non-turbid) water deeper than maximum storm wave base (Brett et al., 1990). Common *Athyris spiriferoides* within the Spring Brook interval itself, while this form is lacking above and below, as well as the presence of small rugose corals, bryozoans, and larger spiriferids such as *Mediospirifer* in the interval in western (shallower) sections, indicates that the Spring Brook Interval represents a small-scale shallowing episode superimposed on an overall deepening trend recorded by the upper part of this submember (Batt, 1996).

Beds B1 through B6 of the Buffalo Creek Submember comprise one meter of fossil-poor dark gray (western sections) to black shale that records the greatest depths for the study interval. A three-fold division reflecting superimposed smaller-scale cycles is indicated by faunal trends, with even smaller-scale cycles discernable in western sections where bed resolution is greatest. Deep bottoms are indicated by the high relative abundance of the rhynchonellid *Eumetabolatoechia multicosta* in the

upper part of the interval in eastern sections; Brett et al. (1990) considered this form to characterize deep, dysaerobic conditions.

The Milestrip Road Bed (beds B7 and B8), a thin (to 0.5 m) interval of dark gray to nearly black shale with bedding planes covered by styliolinids and (except at Kashong Glen) a sparse *Mucrospirifer*-dominated macrofauna, records bypass-related condensation during a shallowing pulse. Calcareous concretions are found in this interval in western sections, where shallower bottoms are indicated by the presence of the orthid *Tropidoleptus* and small rugose corals. An up-section increase in *Athyris* and chonetid brachiopods in the overlying dark gray to black shale (beds B9-B11) signals a small-scale deepening pulse superimposed on overall lower Buffalo Creek Submember shallowing; in western sections even smaller-scale subcycles may be discerned.

The Blasdell Bed, with a highly diverse shallow-bottom fauna, records peak Buffalo Creek Submember regression. Western sections include as many as 20 beds of somewhat calcareous gray shale totaling 1.5 m in thickness (Fig. 4), but the interval thins dramatically eastward and the number of recognizable beds decreases. Faunas and lithology divide the Blasdell Bed into lower and upper parts (see Fig. 9), each representing a superimposed smaller-scale regressive-transgressive cycle.

The lower part of the Blasdell Bed (beds B12-B16) includes three cyclic packages discernable in western sections. The basal one contains a diverse fauna with small rugose corals, bryozoans, large spiriferids, *Mucrospirifer*, and *Athyris*. The middle one was named the "*Demissa* Bed" by Grabau (1898-99) for *Stropheodonta demissa*, a common species in this bed as far east as Genesee County. The upper package includes diagenetic limestone bands and concretions as far east as Cazenovia Creek. Grabau named this interval the "*Stictopora* Limestone" for the abundance of the bryozoan *Sulcoretipora* (*Stictopora*), which may indicate increased turbidity levels associated with sea level fall. The "*Stictopora* Limestone" marks the top of the Wanakah Shale at Lake Erie (Fig. 4) where all overlying beds, as well as the entire Spafford and Jaycox members, are absent in the sub-Tichenor unconformity.

The upper Blasdell Bed (beds B17-B20) records the shallowest bottoms during upper Wanakah deposition, with common *Spinocyrtia granulosa* (a large spiriferid typical of depths close to normal wave base), *Sulcoretipora*, and diverse pelecypods in western sections and the appearance of the small tabulate coral *Pleurodictyum* to the east. Miller (1990) suggested that this coral may have favored higher turbidity levels, so its occurrence may be a good indicator of shallowing conditions and associated increased turbidity. This interval includes three superimposed subcycles, the tops of which are marked by concretion horizons at Rush Creek. The upper Blasdell Bed marks the top of the Wanakah Shale at Rush, Smoke, and Cazenovia creeks, where it is unconformably overlain by Spafford-equivalent shales.

Dark gray shale of the Bloomer Creek Bed (beds B21 and B22), present from Buffalo Creek eastward (Fig. 5), records a small-scale shallowing-deepening cycle during overall transgression. The upper part locally contains corroded, reworked concretions (Baird, 1981) associated with a maximum flooding surface (Brett and Baird, 1994). The lower part of the overlying Romulus Bed (beds B23-B30) contains black shale with numerous pavements of the diminutive spiriferid *Crurispina nana*. Its basal contact is everywhere marked by a sharp lithologic and faunal break, and east of Elevenmile Creek a thin (less than 1 cm) clay may represent a bentonite. The Romulus Bed appears to be

conformable with beds above and below at Hopewell Gully and Kashong Glen, but significant condensation of the lower part is evident westward. The upper two beds contain relatively few *C. nana* compared to other faunal components and in western sections appear to be separated from beds below by a sharp hiatus. The uppermost bed in turn appears to have been erosionally removed in western sections prior to deposition of the Spafford Member.

The Spafford Member in its type area in east-central New York records a cycle of sea level change of at least the same magnitude as the Buffalo Creek Submember (Brett, pers. comm.), but much of the upper part appears to have been removed in the study area. The Limerick Road Bed (beds S1-S4) is a medium gray silty mudstone containing a shallow-water fauna with large spiriferids, gastropods, pelecypods, *Pleurodictyum*, and *Reptaria*-encrusted orthoconic nautiloids. *Mucrospirifer*, *Tropidoleptus*, and chonetids become prominent west of Hopewell Gully. The bed appears to be traceable at least as far west as Jaycox Run; Brett (pers. comm.) noted its erosional truncation near East Bethany. The upper part of the Spafford Member (beds S5-S8) in the study area includes silty gray shale deposited at greater depths than the Limerick Road Bed. All but two basal beds of the upper Spafford were removed by pre-Jaycox erosion at Jaycox Run. Further west, a few beds of silty bluish gray mudstone containing a very sparse *Mucrospirifer*-dominated fauna rests sharply on the beveled upper surface of the Wanakah Shale (Fig. 6) and appears to correlate with the Spafford Member. More work is needed to determine whether this thin interval belongs entirely to the upper part of the Spafford (indicating an erosion interval that removed the Limerick Road Bed) or may include a localized westward reappearance of part of the Limerick Road Bed.

Overall regression apparently followed deposition of the upper part of the Spafford Shale preserved in the study area, but rocks recording this appear to have been removed during sea level lowstand prior to deposition of the overlying Hills Gulch Bed. The Jaycox Member appears to record a single major sea level rise/fall cycle with a scale comparable to the Spafford Member or Buffalo Creek Submember cycles. This unit thins dramatically westward from Kashong Glen due to the removal of progressively older beds by pre-Tichenor erosion (Fig. 7).

The Hills Gulch Bed (bed J1), deposited during early transgression, is a prominent marker traceable westward into Erie County before it disappears in the pre-Tichenor unconformity. Its westward gradation from massive calcareous siltstone through silty limestone to bluish gray encrinal limestone reflects an upslope facies change. The fauna is dominated in eastern sections by mollusks (Figs. 12, 13); large rugose (*Heliophyllum*, *Eridophyllum*) and tabulate (*Favosites*) corals dominate to the west. The bed is represented at Smoke Creek by a thin (to 5 cm) limestone immediately underlying the Tichenor; it is only locally present and much thinner at Rush Creek.

Deepening after Hills Gulch deposition is recorded by a thin dark gray *Zoophycos*-swirled mudstone with *Mucrospirifer* and *Tropidoleptus* (bed J2), overlain by a thin dark gray to black shale interval (bed J3) with pavements of *Tropidoleptus* and the chonetid *Longispina deflecta*. A meter-thick dark gray shale interval (beds J4 and J5) with a fauna dominated by bryozoans (*Sulcoretipora* at Kashong Glen; fenestellids to the west) records a smaller-scale shallowing-deepening cycle. West of Jaycox Run, the shales above the Hills Gulch Bed are represented by whatever survived beveling prior to deposition of the Greens Landing Coral Bed. At Elevenmile Creek, 25 cm of shale are present; at Buffalo Creek only 2 to 4 cm. Further west, the Hills Gulch Bed (where present) is directly overlain by the next limestone bed.

The Greens Landing Coral Bed (beds J6 and J7) records temporary shallowing. It is nearly 0.5 m in the two easternmost sections, where it contains three fossil-rich intervals dominated by bryozoans (*Sulcoretipora* at Kashong Glen; fenestellids at Hopewell Gully) with common small rugose corals (*Amplexiphyllum*, *Stereolasma*), pelecypods, and *Mucrospirifer* (Fig. 13). The interval is represented at Jaycox Run by a 30-cm bed of hard, medium gray calcareous shale with a diverse fauna including large rugose corals (*Heliophyllum*, *Eridophyllum*), small favositids, and *Pleurodictyum*. At Buffalo Creek, the Greens Landing Coral Bed is a massive bluish gray limestone that rests on beveled remains of the underlying shale; it rests directly on the Hills Gulch Bed at Cazenovia Creek. Rapid lateral variations in thickness (from 0 to 12 cm) at these localities reflect irregular erosional scour on the shallow western shelf. The bed is absent at Elevenmile Creek and west of Cazenovia Creek.

Up to 40 cm of gray shale (bed J8) records post-Greens Landing deepening, but above this a bed (bed J9) with large spiriferids, *Pentamerella*, *Megastrophia concava*, small rugose corals, and crinoid debris ("Sponge-*Megastrophia* Bed" of Mayer, 1989) represents a smaller-scale regressive pulse. The greatest depths during Jaycox Member deposition may be represented by dark gray shales (beds J10-J14) with a diverse fauna and abundant crinoid debris. Faunal trends indicate smaller-scale subcycles. Most of the shale above the Greens Landing Coral Bed was removed by erosion in Erie County; a maximum of 5 cm was recorded at Buffalo Creek, and less than 2 cm at Cazenovia Creek.

The Cottage City Coral Bed (beds J15-J17) includes 70 cm of dark gray silty shale at Kashong Glen, where three fossil-rich beds contain a *Sulcoretipora*-dominated fauna with *Tropidoleptus*, small rugose corals, and crinoid debris (Fig. 13). The interval thins to 50 cm at Jaycox Run (Fig. 7), where the fossil beds are limey to concretionary and contain abundant large rugose corals. At Buffalo and Cazenovia creeks, the equivalent interval is a single massive bluish gray limestone that (where present) reaches a maximum thickness of 12 cm.

The remainder of the Jaycox Member (beds J18-J22) includes 7.5 m of *Zoophycos*-swirled silty mudstone at Kashong Glen where it records continued shallowing. There the fossil-poor upper few meters were not accessible for sampling, but the lower part contains a fauna with *Mucrospirifer*, chonetids, gastropods, and *Pleurodictyum*. Faunal dominance trends indicate at least one superimposed subcycle. This upper Jaycox thins dramatically westward beneath the pre-Tichenor erosion surface (Fig. 7); at Hopewell Gully, less than 1 m remains. At Jaycox Run, only about 45 cm of shale separates the Cottage City Coral Beds from the Tichenor, and 0 to 8 cm of dark gray shale represents this interval at Buffalo Creek and Cazenovia Creek.

CONCLUSIONS

Lithologic and faunal patterns reveal a hierarchy of cyclic packages in the upper part of the Ludlowville Formation (Fig. 14). Superimposed on an overall regression are several member- or submember-scale cycles. Numerous smaller-scale subcycles can be traced across most of the study area. An even smaller-scale cyclicity is observed where bed resolution is greatest. Comparison of the cyclic packages with the correlation-derived chronostratigraphy suggests that they are isochronous, with peak transgressions peak regressions recorded in the same bed along the 140-km transect. The cyclicity thus appears to reflect sea level fluctuations responding to regional or perhaps global controls. For a discussion of magnitudes, durations, and causal mechanisms of cycles recorded in Hamilton Group rocks, the reader is referred to papers by Batt (1996), Brett (1995, 1998), and Miller (1990).

Microstratigraphic correlation and cyclic interpretations allow a detailed reconstruction of events prior to deposition of the Tichenor Member, including at least seven distinct episodes of erosional scour and/or condensation (Fig. 15). The top of the Bloomer Creek Bed is believed to represent a maximum flooding surface associated with submember-scale transgression accompanied by basin-wide starvation as sediment was trapped in newly flooded embayments. Condensation of the lower Romulus Bed from Jaycox Run westward may record sediment bypass affecting shallower areas during subsequent sea-level fall.

Each of the five erosion surfaces in the remainder of the study interval records scour during a lowstand event. In each case, successively older beds were beveled in a westward direction where progressively shallower bottoms were more directly influenced by storm waves during sea level fall. Pre-Spafford erosion removed the uppermost Romulus Bed from Jaycox Run to Buffalo Creek; further west, the entire Bloomer Creek through Romulus interval is absent. The unconformable base of the Hills Gulch Bed from Jaycox Run westward reflects erosion during lowstand associated with the Spafford cycle, even though a thin interval of mudstone probably equivalent to part of the Spafford Member persists as far west as Rush Creek. The erosional bases of the Greens Landing and Cottage City coral beds also represent lowstand events, with westward removal of progressively older underlying shales until, at Cazenovia Creek (and locally at Buffalo Creek), the coral bed rests directly on remnants of the limestone of the previous cycle. The intermittent persistence of these limestones as far west as Cazenovia Creek suggests that they may have been locally indurated prior to re-exposure on the sea floor as somewhat resistant hardgrounds.

Erosion during final pre-Moscow lowstand affected the entire area of study. The sub-Tichenor unconformity not only truncates successively older beds but also oversteps older erosion surfaces to create a westward merging of unconformities until only one is present at the Lake Erie shore, where the Tichenor Member rests directly on a beveled surface near the top of the lower Blasdell Bed (Fig. 15). This overall pattern is very similar to that noted by Brett and Baird (1982) for the top of the Hamilton Group in western and central New York.

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ROAD LOG AND STOP DESCRIPTIONS

The road log begins at the first stop, at Jaycox Run. From Fredonia: New York State Thruway (I-90 E) to Exit 48 (Batavia) (68 mi); Rt. 98 S to Batavia (2 mi); left (S) on Rt. 63. Pass through Pifford in 24.5 mi; 2.4 mi further turn left onto Court Street in Geneseo. In 0.5 mi turn left (N) onto Rt. 39. Pass Nations Road on left in 2 mi. White Devon Farm 0.5 mi further; turn around and park across from farm on shoulder near gateway into pasture. Walk straight west from gate through the pasture to a cluster of oak trees along the south branch of Jaycox Creek.

Note: Section descriptions for stops are arranged from the top bed downward. Corresponding depositional units discussed in text are provided for each interval described. Prominent fossils are listed for each bed; these are not complete faunal listings.

STOP 1: JAYCOX RUN

Exposures along the south fork of Jaycox Creek, on the property of William P. Wadsworth (White Devon Farm), about 0.8 km (0.5 mi) north of Nations Road, Geneseo, Livingston County, NY. This site is PRIVATE PROPERTY; in order to collect, PERMISSION MUST BE OBTAINED.

This section, the eastern-most one we will visit, illustrates all of the members and major marker beds of the study interval. Some of the beds present in sections further east have already been removed here in various unconformities.

SECTION DESCRIPTION:

J15-J17 94 cm COTTAGE CITY CORAL BED
Three limey, fossil-rich beds, each overlain by an interval of less fossiliferous shale. Corals: *Heliophyllum*, *Eridophyllum*, *Cystiphylloides*, *Amplexiphyllum*, *Stereolasma*, *Favosites*. Bryozoans: fenestellids, *Sulcoretipora*, *Lichenalia*. Brachiopods: *Pentamerella*, *Parazyga*, *Mesoleptostrophia*, *Protodouvillina*, *Athyris*, *Devonochonetes*, *Rhipidomella*. Trilobites: *Phacops*, *Monodechenella*. Abundant crinoid debris. > 20 species identified from these beds.

J10-J14 77 cm Several beds of hard shale with two prominent fossil-rich horizons. Corals: *Amplexiphyllum*, *Stereolasma*, *Aulocystis*; bryozoans: fenestellids, *Sulcoretipora*, *Lichenalia*; brachiopods: *Devonochonetes*, *Stropheodonta*, *Mesoleptostrophia*, *Protoleptostrophia*, *Protodouvillina*, *Mucrospirifer*, *Mediospirifer*, *Pentamerella*, *Parazyga*); mollusks, trilobites, abundant crinoid debris. Beds contain more than 30 species.

J9 31 cm "SPONGE-*MEGASTROPHIA* BED"
6 cm shell bed overlain by 25 cm shale. Corals: *Eridophyllum*, *Amplexiphyllum*; bryozoans: fenestellids, *Lichenalia*; brachiopods: *Megastrophia*, *Mesoleptostrophia*, *Stropheodonta*, *Orthospirifer*, *Parazyga*, *Pentamerella*; trilobites: *Phacops*, *Greenops*. Abundant crinoid debris. 22 species.

J8 29 cm Medium gray hard fissile shale with crinoid debris. 16 species noted, dominantly fenestellids, *Stereolasma*, *Protodouvillina*, *Phacops*, *Monodechenella*.

J6-J7 30 cm GREENS LANDING CORAL BED
Hard medium gray shale with abundant crinoid debris. More than 30 species noted. Corals: *Heliophyllum, Cystiphylloides, Cyathophyllum, Eridophyllum, Thamnoptychia, Favosites, Pleurodictyum*; bryozoans: fenestellids, *Sulcoretipora, Lichenalia*; brachiopods: *Protodouvillina, Orthospirifer, Pentamerella, Parazyga*. *Phacops* the dominant trilobite.

J2-J5 50 cm Three beds hard fissile medium gray shale; more than 35 species. Corals: *Amplexiphyllum, Cyathophyllum, Favosites, Pleurodictyum*; bryozoans: fenestellids, *Sulcoretipora, Lichenalia*; brachiopods: abundant *Tropidoleptus* and chonetids; also *Mediospirifer, Orthospirifer, Rhipidomella, Pentamerella, Athyris*. Various gastropods and pelecypods. Trilobites: *Phacops, Dipleura*. Crinoid debris rare.

J1 28 cm HILLS GULCH BED
Hard massively fissile bed at top of waterfall. More than 30 species. Corals: *Amplexiphyllum*, aulocystids; bryozoans: fenestellids; brachiopods: *Orthospirifer, Athyris, Parazyga*; pelecypods: *Pseudaviculopecten, Actinopteria, Mytilarca, Pterinopecten, Grammysioidea, Gosseletia, Cypricardella, Modiomorpha*; gastropod: *Mourlonia*; cephalopod: *Nephriticerina*; trilobite: *Phacops*. Crinoid debris very rare.

S5-S6 45 cm Upper part of Spafford shale. Two beds of hard bluish gray, massively fissile shale with few fossils. 12 species noted. Coral: tiny *Pleurodictyum*; brachiopods: *Mucrospirifer, Tropidoleptus, Euschuchertella*, chonetids, *Mediospirifer, Cupularostrum*; pelecypod: *Nuculoidea*; gastropod: *Euryzone*; orthoconic nautiloid.

S1-S4 37 cm LIMERICK ROAD BED
Represented here by two beds of hard medium gray, *Zoophycos*-swirled shale with more than 20 species. Coral: *Pleurodictyum*; brachiopods: *Mucrospirifer, Tropidoleptus, Protoleptostrophia, Mediospirifer, Orthospirifer, Athyris, Cupularostrum*; mollusks (*Nuculoidea, Nuculites, Grammysioidea, Palaeozygopleura, Euryzone, Mourlonia*, orthocones. Crinoid debris rare.

B29 18 cm UPPER ROMULUS BED
Soft dark gray shale with less than 20 species. Brachiopods: *Mucrospirifer, Athyris, Mediospirifer, Orthospirifer, Cupularostrum*; gastropods (*Mourlonia, Palaeozygopleura*; cephalopods (orthoconic nautiloids, *Agoniatites*. Base marked by prominent granular pavement of *Crurispina nana* (condensed upper part of lower Romulus Bed).

B23-B25 49 cm LOWER ROMULUS BED
Represented here by 2 beds of hard dark gray fissile shale with several closely-spaced pavements of *Crurispina nana* (>90% of fauna). Also chonetids, *Mucrospirifer, Eumetabolatoechia, Euryzone*. Thin (<1 cm) clay at base may represent bentonite.

B21-B22 7 cm BLOOMER CREEK BED
Hard medium gray fissile shale with 14 species: *Mucrospirifer*, chonetids, *Cupularostrum*, gastropods (*Euryzone, Retispira*), trilobites (*Phacops, Greenops*).

B17-B20 19 cm UPPER BLASDELL BED
Two beds of hard medium gray fissile shale, more than 20 species. Corals: *Stereolasma*, *Pleurodictyum*; bryozoan: *Sulcoretipora*, brachiopods: *Mucrospirifer*, chonetids, *Orthospirifer*, *Athyris*, *Eoschuchertella*, *Rhipidomella*; mollusks (*Euryzone*, *Mourlonia*, *Palaeozygopleura*, orthocones); *Phacops*. Rare crinoid ossicles.

B12-B16 24 cm LOWER BLASDELL BED
Represented here by two beds of softer medium gray fissile shale, more than 20 species. Corals: *Stereolasma*, *Aulocystis*, small *Pleurodictyum*; bryozoans: *Sulcoretipora*, fenestellids; brachiopods: *Mucrospirifer*, chonetids, *Orthospirifer*, *Athyris*, *Ambocoelia*, *Pseudoatrypa*; mollusks (*Paleoneilo*, *Pterinopecten*, orthocones); abundant *Phacops*, rare crinoid ossicles.

B9-B11 14 cm Represented here by single bed hard dark gray shale with 7 species dominated by *Mucrospirifer*, *Sinochonetes*, with *Cyrtina*, common orthocones, *Phacops*. No crinoid debris.

B7-B8 23 cm MILESTRIP ROAD BED
Two beds hard dark gray thinly fissile shale with <10 species: *Eumetabolatoechia*, *Mucrospirifer*, *Sinochonetes*, orthocone, *Palaeozygopleura*, *Phacops*. Abundant blastoid stem material in lower part. Bedding planes covered with *Styliolina*.

B1-B6 67 cm Several beds of soft dark gray thinly fissile shale with <10 species. Brachiopods: *Eumetabolatoechia*, *Ambocoelia*, *Mucrospirifer*, *Sinochonetes*. Also *Palaeozygopleura*, orthocones, *Phacops*. Abundant styliolinids.

H1-H3 23 cm SPRING BROOK INTERVAL
Hard dark gray thinly fissile shale with 5 species. *Ambocoelia* dominant, with *Mucrospirifer*, *Sinochonetes*, *Phacops*.

Return to vehicles and CONTINUE SOUTH ON RT. 39

MILEAGE:		INSTRUCTIONS:
0.0	0.0	White Devon Farm at Stop 1.
0.5	0.5	Nations Road on right. Continue south on Rt. 39.
2.0	2.5	Court Street in north Geneseo (by courthouse). Turn right.
0.5	3.0	Jct. with Rt. 63. Turn right.
2.4	5.4	Pass through Pifford.
1.5	6.9	Retsof mine site. Continue on Rt. 63.
0.8	7.7	Griegsville Corners. Turn right (north) onto Rt. 36.

2.8	10.5	York Road in York. Turn left.
1.1	11.6	Turn right onto Limerick Road.
0.2	11.8	STOP 2. Limerick Road site.

STOP 2: LIMERICK ROAD SITE (Optional)

Creek on the property of Robert Walton, York, Livingston County, NY.

This stop, not included in the investigation, provides an additional exposure of the Spafford and Jaycox members. Section similar to that described for Jaycox Run.

Return to York.

MILEAGE:		INSTRUCTIONS:
1.4	13.2	Turn left in York onto Rt. 36, proceed north.
4.0	16.2	Turn left (west) onto US 20.
4.2	20.4	Turn left (south) onto Asbury Road.
0.45	20.85	Turn right (west) onto Murry Road.
0.15	21.0	Turn right onto driveway.
0.1	21.1	Stop at house.

STOP 3: HILLS GULCH

Creek on the property of Carl Hume, Union Corners, Genesee County, NY.

This site, not included in the investigation, exposes the interval from the upper part of the Buffalo Creek Submember through the Tichenor Member. The general section is described below (thicknesses approximate):

SECTION DESCRIPTION:	
(not meas.)	Tichenor Member at top of waterfall.
17 cm	Cottage City Coral Bed. Only the lowest of the three coral beds remains after pre-Tichenor erosion.
130 cm	Middle part of Jaycox Member between coral beds.

30 cm	Greens Landing Coral Bed. Numerous large, often elongate and constricted *Heliophyllum*, also *Eridophyllum*, *Favosites*.
17 cm	Shale between Greens Landing Bed, Hills Gulch Bed
25-30 cm	Hills Gulch Bed. Hard silty mudstone with abundant fossils: *Mucrospirifer*, large spiriferids, *Phacops*.
30 cm	Upper part of the Spafford Member. Hard light gray massively fissile, poorly fossiliferous shale.
25 cm	Limerick Road Bed. Bluish gray silty mudstone, *Pleurodictyum*, large spiriferids.
27 cm	Upper Romulus Bed. Soft fissile shale.
75 cm	Lower Romulus Bed. Several beds of soft, thinly fissile shale; pavements of *Crurispina*.
25 cm	Bloomer Creek Bed. Hard fissile shale with *Athyris*, *Mucrospirifer*.
50 cm	Blasdell Bed. Fissile shale with *Sulcoretipora*, *Phacops*, diverse brachiopods.
30 cm	Shale below Blasdell Bed to creek level.

Return to vehicles and return to Jct. Asbury Road and US 20.

MILEAGE:		INSTRUCTIONS:
0.7	21.8	Turn left (west) onto US 20 from Asbury Road.
5.0	26.8	Texaco Town, Jct. Rt. 63 and US 20. Continue on US 20.
3.3	30.1	Old Telephone Road at Bethany Center. Continue on US 20.
6.4	36.5	Jct. US 98, Alexandria. Continue on US 20.
4.9	41.4	Darien. Continue on US 20.
1.9	43.3	Jct. 77, Darien Center. Continue on US 20.
1.7	45.0	Cross Elevenmile Creek.
0.5	45.5	Entrance to Darien Lake State Park on right. Continue on US 20.
2.7	48.2	Pass John and Mary's on left.

0.3	48.5	Crittendon Road in Alden. Continue on US 20.
0.3	48.8	Fork in Alden; stay on US 20 (bear left).
2.9	51.7	Two Rod Road (Marilla sign). Turn left (S).
2.5	54.2	Clinton Street (stop sign). Continue on Two Rod Road.
0.7	54.9	Enter Marilla.
0.4	55.3	Bullis Road. Turn right (west).
2.1	57.4	Stolle Road. Continue on Bullis Road.
0.1	57.5	Turn left onto access to old bridge over Buffalo Creek (closed), just before Bullis Road bridge. Park before barricade. DO NOT BLOCK DRIVEWAY! If there is not enough room, continue on Bullis Road across creek, turn sharp left onto access road to other end of old bridge. Walk down to east end of old bridge, take path downstream, then down to creek bank at base of waterfalls.

STOP 4: BUFFALO CREEK AT BULLIS ROAD

Buffalo Creek beneath and downstream of Bullis Road bridge, Marilla, Town of Elma, Erie County, NY.

This exposure illustrates the continued westward removal of successively older beds during lowstand events. Most dramatic is the removal of almost all of the shale overlying the Hills Gulch Bed, Greens Landing Coral Bed, and Cottage City Coral Bed. Each of these beds is here represented by a massive fossiliferous limestone characteristic of this shallower western shelf setting. This section also marks the westernmost occurrence of the Bloomer Creek Bed and Romulus Bed of the Buffalo Creek Submember.

SECTION DESCRIPTION:

Note: The Jaycox Member was not sampled for fossils in this investigation, so bed prefixes were not assigned.

TICHENOR LIMESTONE. Massive gray limestones. To 50 cm.

Hard bluish gray shale: remains of Jaycox Member above the Cottage City Coral Bed. Locally absent. 0-8 cm.

COTTAGE CITY CORAL BED. Variable thickness over short distances. Massive bluish gray limestone with large corals (rugose and *Favosites*), crinoids, other fossils. 0-12 cm.

Hard bluish gray shale (escaped pre-CCC Bed erosion). 0-5 cm.

GREENS LANDING CORAL BED. Thickness varies over short distances. Locally the lowest limestone in the waterfall. Fossils similar to Cottage City Coral Bed. 0-15 cm.

Hard bluish gray shale (escaped pre-GLC Bed erosion). 0-8 cm.

HILLS GULCH BED. Massive bluish gray limestone with abundant fossils: crinoid debris, bryozoans, brachiopods (*Elita, Parazyga, Protodouvillina, Pholidostrophia, Megastrophia*), mollusks (*Actinopteria, Platyceras*), corals (*Heliophyllum, Favosites, Pleurodictyum*). 0-16 cm.

S1?-S6? 95 cm PROBABLE SPAFFORD EQUIVALENT
Top two beds (locally absent) massively fissile bluish gray shale with few fossils (*Mucrospirifer*, chonetids, *Agoniatites*). Lower beds hard, thinly fissile dark gray shale with *Mucrospirifer*, *Cupularostrum*, chonetids, tiny *Tropidoleptus*, *Cyrtina*, nuculids.

B29 16 cm UPPER ROMULUS BED
Soft dark gray thinly fissile shale dominated by *Devonochonetes* and *Mucrospirifer*. Also tiny *Tropidoleptus*, *Crurispina nana*, orthocones, *Agoniatites*. 10 species.

B23-B24 23 cm LOWER ROMULUS BED
Two horizons of widely-spaced irregular concretions studded with *Crurispina nana* in hard, dark gray thinly fissile shale. *C. nana* comprises >80% of fauna of <10 species. Also chonetids, small *Tropidoleptus, Mucrospirifer, Cupularostrum.*

B21-B22 16 cm BLOOMER CREEK BED
Hard fissile medium gray shale with 15 species. Fauna dominated by *Mucrospirifer* and chonetids, with common *Athyris* and *Tropidoleptus*. Also *Cyrtina, Mediospirifer, Pseudoatrypa, Grammysioidea*, various pelecypods, *Phacops*, rare *Stereolasma.*

B17-B20 45 cm UPPER BLASDELL BED
Four beds of hard fissile dark gray shale, >40 species. Coral: *Stereolasma*; bryozoan: *Sulcoretipora*; brachiopods: *Mucrospirifer, Devonochonetes, Rhipidomella, Tropidoleptus, Spinocyrtia, Mediospirifer, Nucleospira, Athyris*; *Phacops*. Crinoid debris rare.

B12-B16 68 cm LOWER BLASDELL BED
Five beds of hard fissile to thinly fissile shale, >40 species. Coral: *Stereolasma*; bryozoans: *Sulcoretipora*, fenestellids; brachiopods: *Mucrospirifer, Rhipidomella, Protodouvillina, Megastrophia, Stropheodonta, Mediospirifer, Spinocyrtia, Cyrtina, Pseudoatrypa, Athyris*; various mollusks, trilobites. Crinoid debris rare compared to sections to west.

B9-B11 26 cm Three beds of thinly fissile dark olive gray shale, <15 species. Dominantly *Mucrospirifer* but *Athyris* quite abundant. Also chonetids, *Mediospirifer, Cyrtina, Nucleospira*, trilobites. Rare *Stereolasma*. No crinoid debris.

B7-B8 49 cm MILESTRIP ROAD BED
Hard dark gray thinly fissile shale, styliolinid-covered surfaces. Widely spaced calcareous concretions at base. <10 species. Dominantly *Mucrospirifer* and *Sinochonetes*, with *Cyrtina, Eumetabolatoechia, Nuculoidea, Grammysioidea, Phacops.*

B1-B6 87 cm Several beds of hard fissile to thinly fissile dark gray shale. Fauna in upper part dominated by *Mucrospirifer*, with chonetids, *Cyrtina, Phacops. Ambocoelia* dominant in lower beds. <15 species.

H1-H3 82 cm SPRING BROOK HORIZON
Represented here by several beds of hard fissile shale. One horizon of flattened calcareous concretions near top; two horizons of larger concretions in lower part. Beds contain up to ten species. Dominated by *Ambocoelia*, with *Mucrospirifer, Sinochonetes, Athyris, Phacops*; rare *Sulcoretipora, Stereolasma, Spinocyrtia*, blastoid stems.

Return to vehicles, continue west on Bullis Road.

MILEAGE:		INSTRUCTIONS:
0.4	57.9	Girdle Road. Continue on Bullis Road.
1.6	59.5	Bowen Road. Continue on Bullis Road.
3.0	62.5	Transit Road (US 20/Rt. 78). Turn left (S).
0.4	62.9	Jct. Rt. 400. Turn right (Rt. 400 W).
5.0	67.9	Jct. NY State Thruway. Take I-90 West.
11.3	79.1	Exit 57 (Hamburg). After toll, take Rt. 75 North.
1.0	80.1	Jct. US 20. Turn left.
4.4	84.5	Detour (US 20 bridge closed). Turn Right onto Lakeview Road.
1.5	86.0	Jct. Rt. 5. Turn Left.
1.1	87.1	Cross Eighteenmile Creek.
0.2	87.3	Jct. South Creek Road. Turn left and park in lot on right. Cross South Creek Road and follow fishing trail under bridge to creekbed (steep). Exposure immediately upstream.

STOP 5: EIGHTEENMILE CREEK AT ROUTE 5

South bank of Eighteenmile Creek immediately upstream of Route 5 bridge, Town of Evans, Erie County, NY. This section, Grabau's Section 6, is similar to the Lake Erie Shore section exposed less than 1 mi to the west. It was chosen because of accessibility. NOTE that the exposures along the creek on the north bank, west of the Route 5 bridge, are on private property and are off-limits.

Here the Tichenor can be seen to rest directly on a beveled surface near the top of the lower part of the Blasdell Bed. The entire Jaycox, Spafford, and upper Wanakah down through the upper part of the Blasdell Bed has been removed by pre-Tichenor erosion. Also visible at this locality is the unconformity separating the Tichenor Member from the overlying Windom Shale, with the intervening Deep Run Shale, Menteth Limestone, and Kashong Shale removed during similar lowstand erosion events.

SECTION DESCRIPTION:

NOTE: Numbered beds referred to in the study were defined at the type locality for the Buffalo Creek Submember. Because resolution is greater at the Lake Erie Shore section, several beds here may correspond to one bed at Buffalo Creek. Example: B15 is represented here by four.

B16 23 cm "*STICTOPORA* LIMESTONE"
Three hard limey beds packed with fossils (>50 species). Prominent fossils include *Sulcoretipora, Mucrospirifer, Nucleospira,* fenestellids, *Phacops, Pseudoatrypa,* crinoids, chonetids, *Stereolasma, Lichenalia, Rhipidomella, Spinocyrtia, Stropheodonta,* mollusks.

B15 22 cm "*DEMISSA* BED"
Four beds of slightly softer medium gray fissile shale with abundant fossils (>50 species). Prominent forms include *Mucrospirifer, Sulcoretipora,* fenestellids, *Stereolasma,* chonetids, *Stropheodonta, Megastrophia, Spinocyrtia, Mediospirifer, Athyris, Pseudoatrypa,* diverse gastropods and pelecypods, orthoconic nautiloids, *Nephriticerina, Phacops, Greenops,* crinoids.

B12-B14 42 cm Shale of basal Lower Blasdell Bed subcycle. Four beds, *Zoophycos*-swirled. >50 species. Brachiopods: *Mucrospirifer, Nucleospira,* chonetids, *Cyrtina, Cupularostrum, Rhipidomella, Pseudoatrypa, Athyris* (abundant), *Spinocyrtia, Megastrophia, Stropheodonta.* Also *Stereolasma,* mollusks.

B9-B11 48 cm Four beds of fissile shale, up to 20 species. Dominated by chonetids and *Mucrospirifer.* Also *Mediospirifer, Athyris, Cyrtina, Nucleospira, Stereolasma* (few), *Greenops, Phacops,* orthocones.

B7-B8 30 cm MILESTRIP ROAD BED
Two beds, each with calcareous concretions at base. Abundant styliolinids. Up to 20 species. *Mucrospirifer, Athyris* (abundant), *Stereolasma, Aulocystis, Protoleptostrophia, Cyrtina,* chonetids, *Phacops, Greenops.*

B1-B6 78 cm Seven beds of fissile dark gray shale. <15 species. *Mucrospirifer* dominates in upper part; *Ambocoelia* in lower part. Also chonetids, small *Tropidoleptus, Cyrtina, Athyris, Eoschuchertella, Aulocystis, Stereolasma, Phacops.*

H1-H3 76 cm SPRING BROOK HORIZON
Six beds of hard dark gray thinly fissile shale, including three horizons of large concretions. <20 species. *Ambocoelia* dominant, with abundant *Athyris,* also *Sulcoretipora, Rhipidomella,* chonetids, *Protoleptostrophia, Mediospirifer, Mucrospirifer, Phacops.*

To return to Fredonia, follow South Creek east to US 20, turn right (west), turn left onto Evans Center/Eden Center Road, get on NY Thruway at Angola exit (57A).

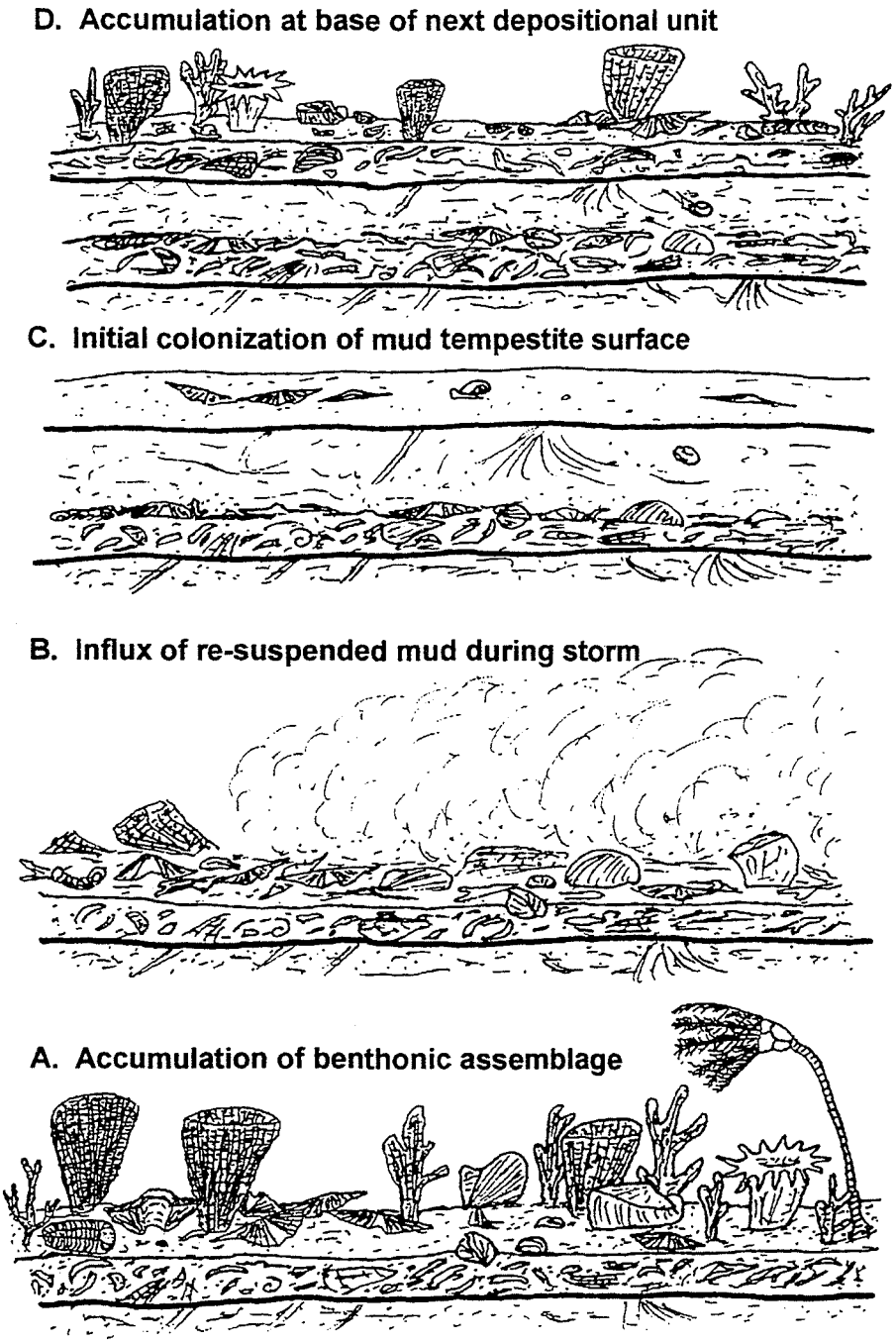


FIGURE 1. Steps in the formation of a typical depositional unit.

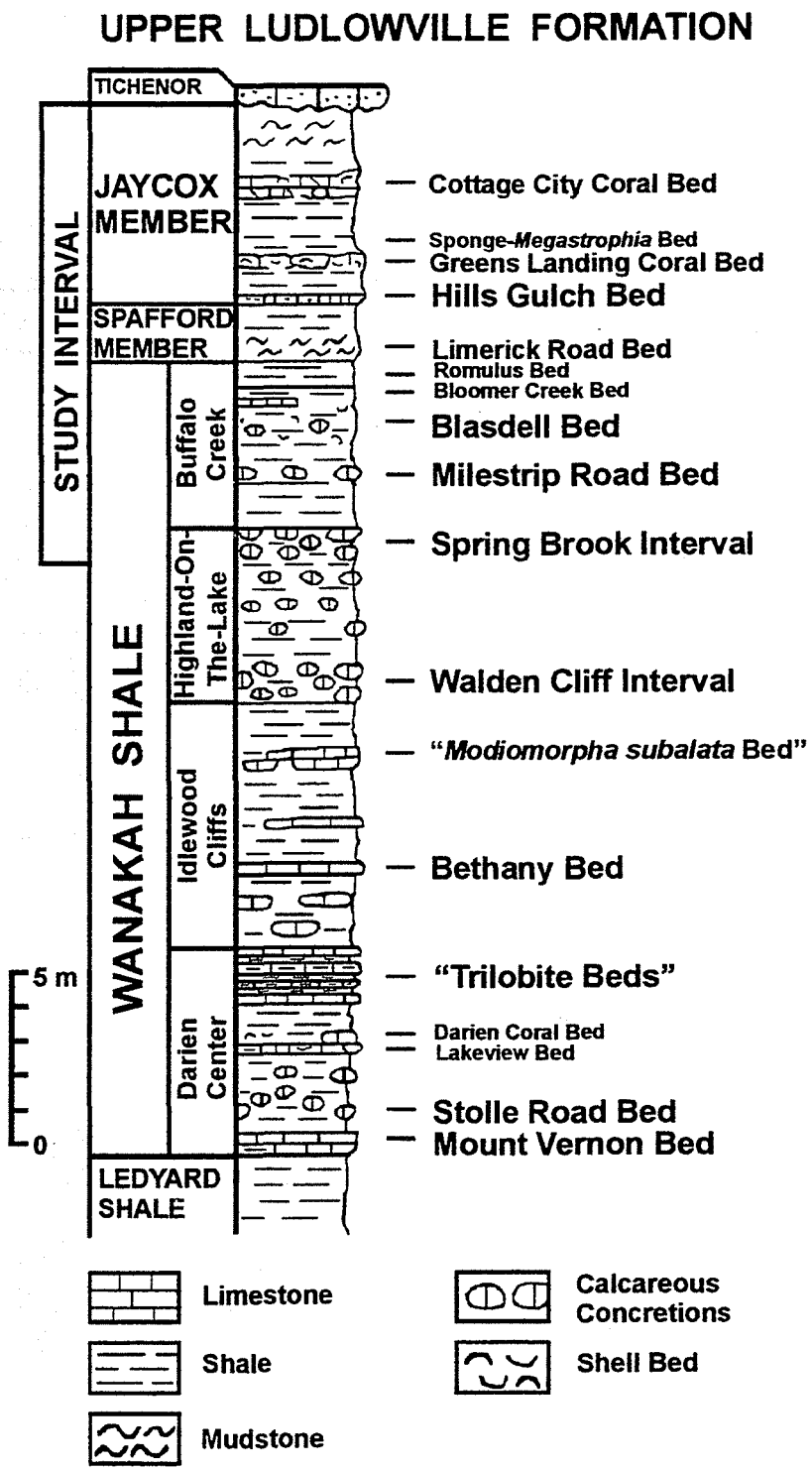


FIGURE 2. Stratigraphic section for the upper part of the Ludlowville Formation. Study interval includes the Spring Brook Interval (uppermost Highland-On-The-Lake Submember), Buffalo Creek Submember, Spafford Member, and Jaycox Member.

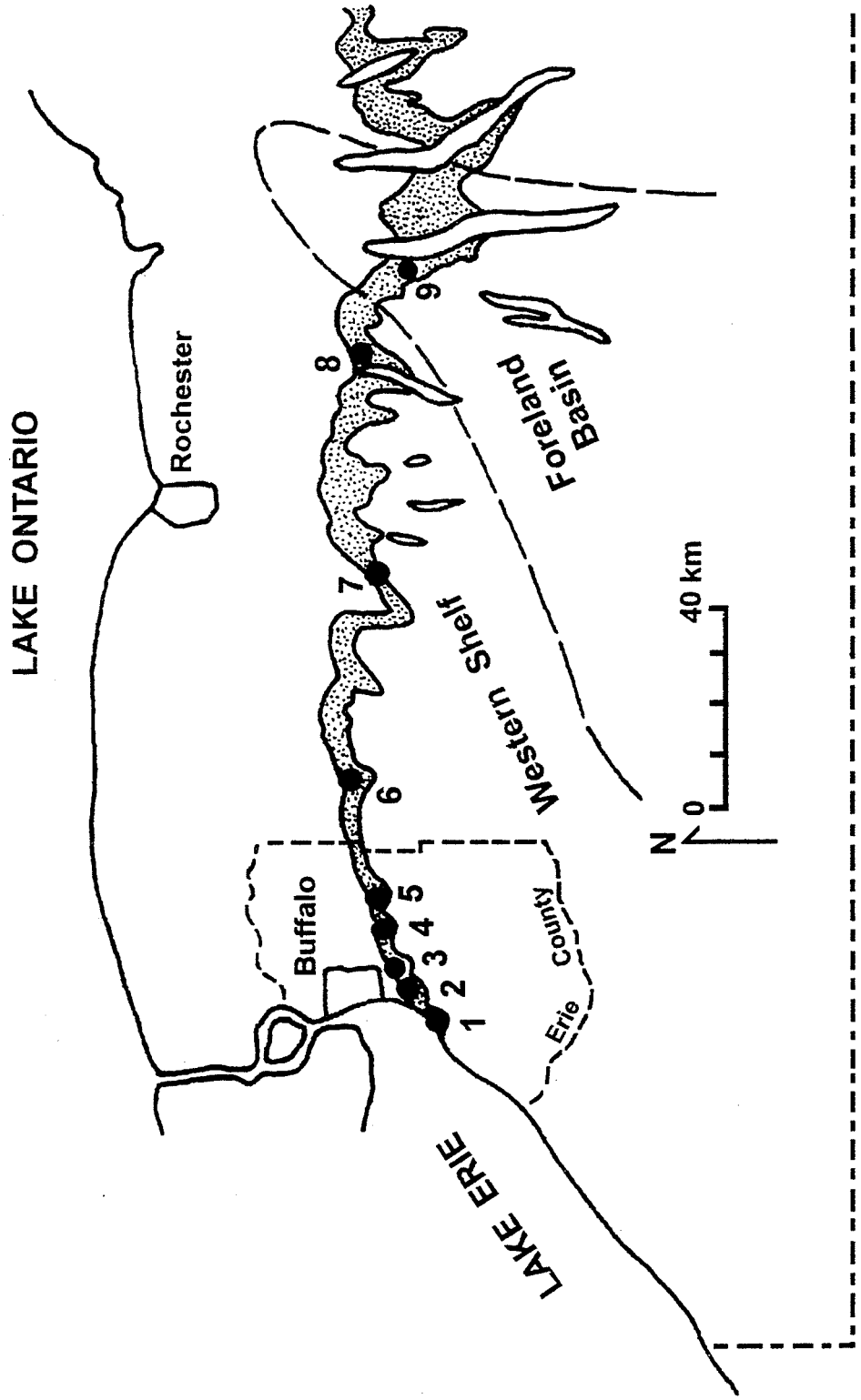


FIGURE 3. Map of study area showing outcrop belt of Ludlowville and Moscow formations (stippled pattern), major paleogeographic features, and location of measured sections: 1) Lake Erie Shore near mouth of Eighteenmile Creek; 2) Rush Creek near Blasdell; 3) Smoke Creek near Windom; 4) Cazenovia Creek near Spring Brook; 5) Buffalo Creek near Elma; 6) Elevenmile Creek near Darien; 7) Jaycox Run near Geneseo; 8) Hopewell Gully near Canandaigua; 9) Kashong Glen near Geneva.

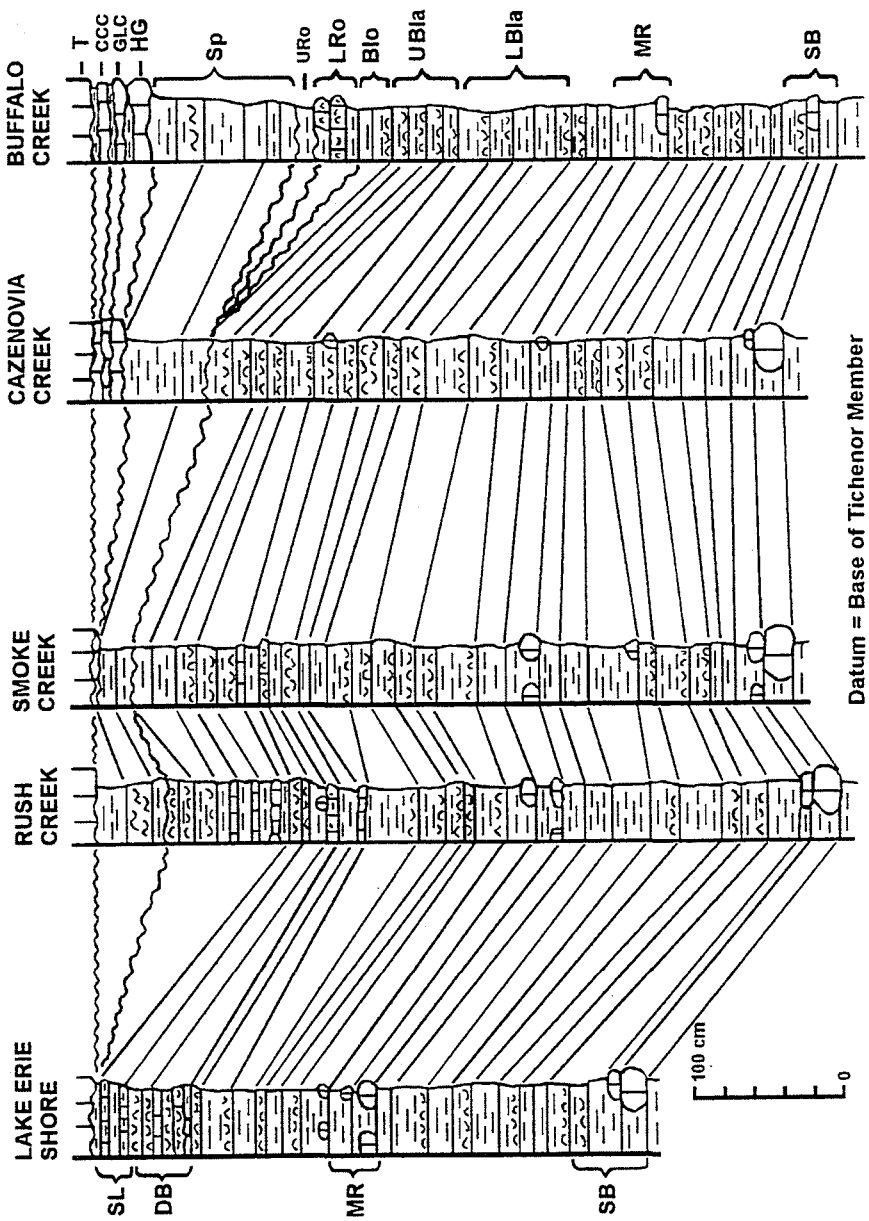


FIGURE 4. Correlation of measured sections through the study interval in Erie County (Lake Erie shore to Buffalo Creek). Marker beds: SB Spring Brook Interval; MR Milestrip Road Bed; LBla lower Blasdell Bed; UBla upper Blasdell Bed; Blo Bloomer Creek Bed; LRo lower Romulus Bed; URo upper Romulus Bed; Sp Spafford Member; HG Hills Gulch Bed; GLC Greens Landing Coral Bed; CCC Cottage City Coral Bed; T Tichenor Member; DB "*Demissa* Bed"; SL "*Stictopora* Limestone".

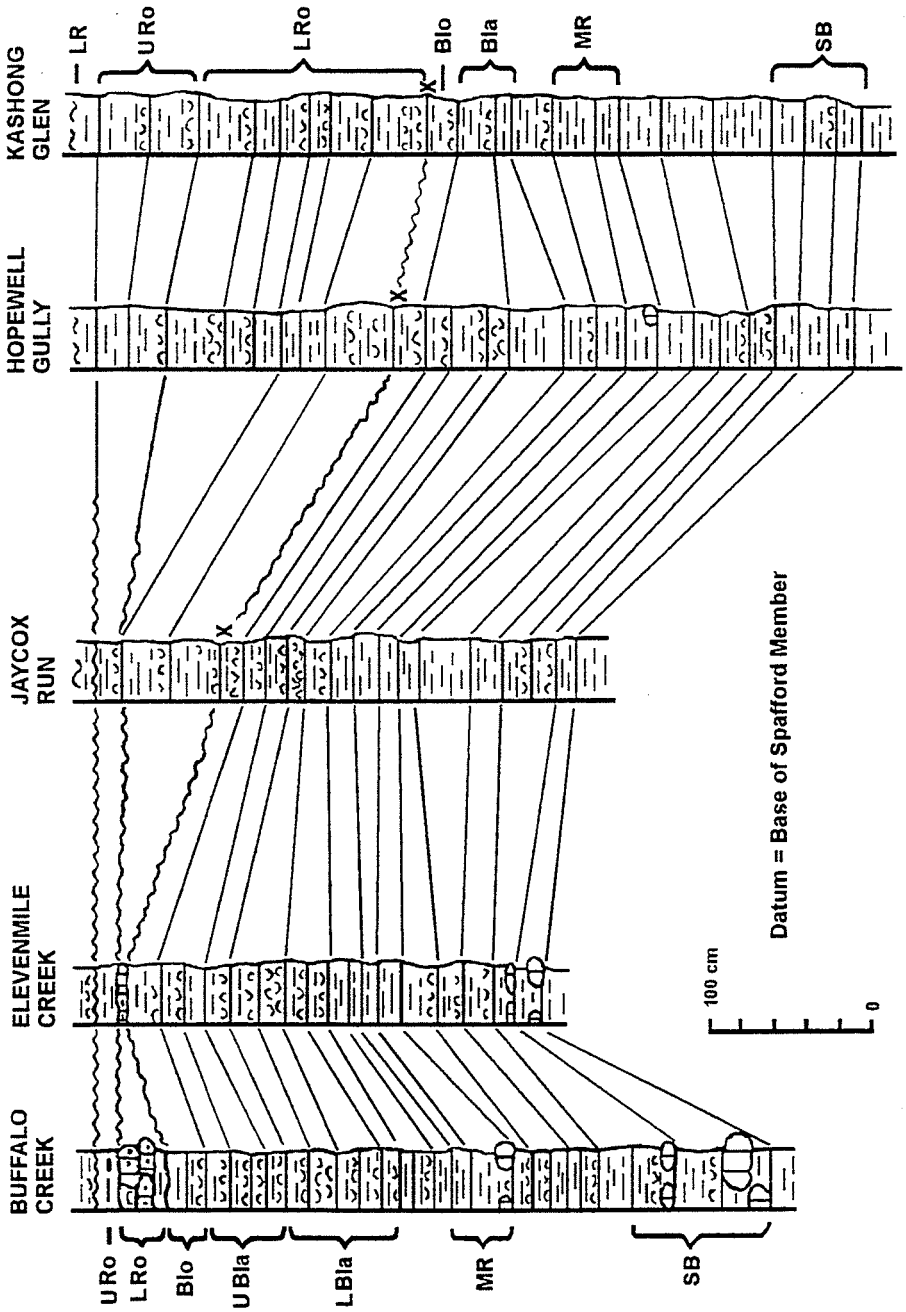


FIGURE 5. Correlation of measured sections through the Wanakah Shale part of the study interval from Buffalo Creek to Kashong Glen. Marker beds defined in Figure 4 caption (Bla represents undifferentiated Blasdell Bed in eastern sections). Position of possible bentonite indicated by "X".

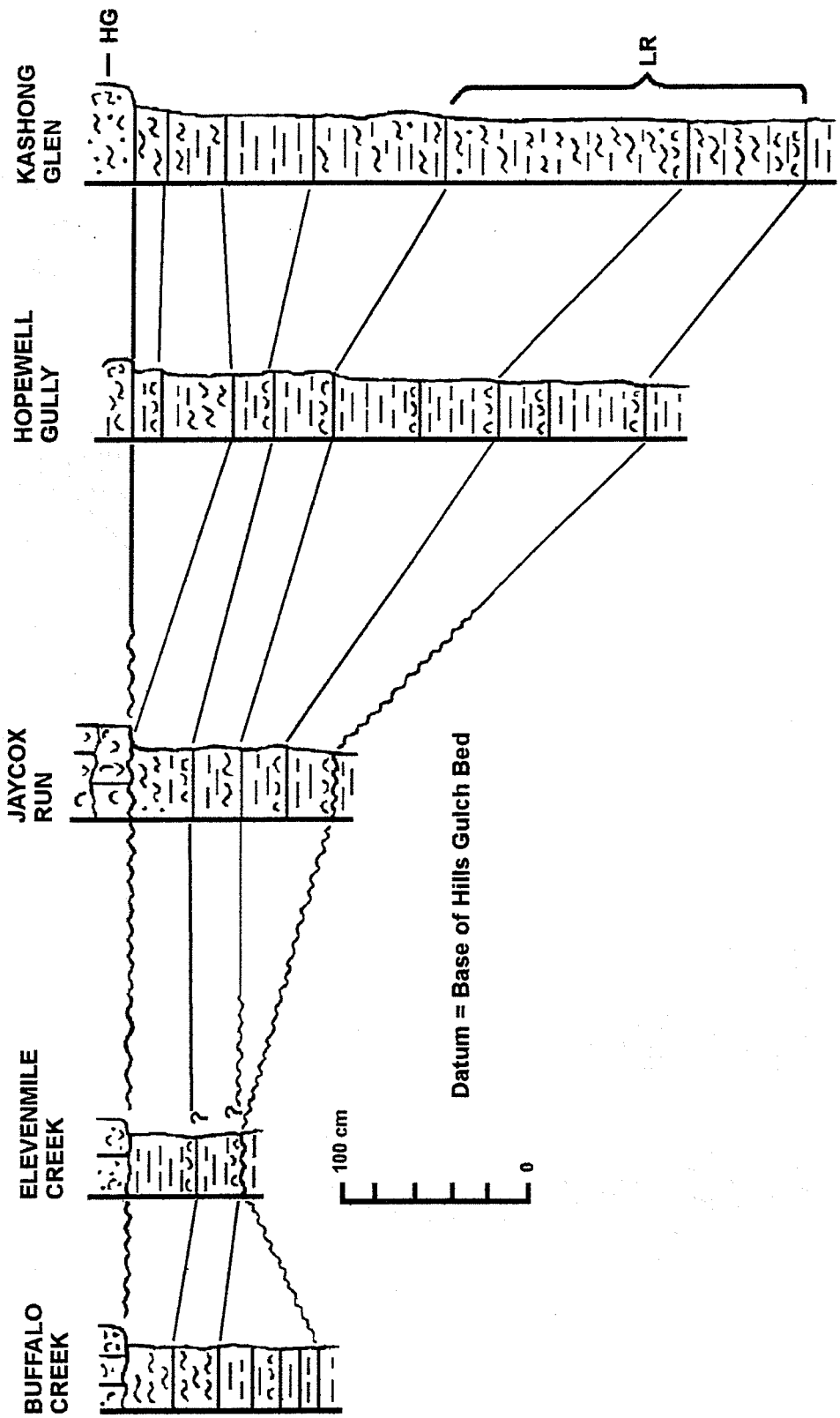


FIGURE 6. Correlation of measured sections through the Spafford Member from Buffalo Creek to Kashong Glen. Marker beds: LR Limerick Road Bed; HG Hills Gulch Bed.

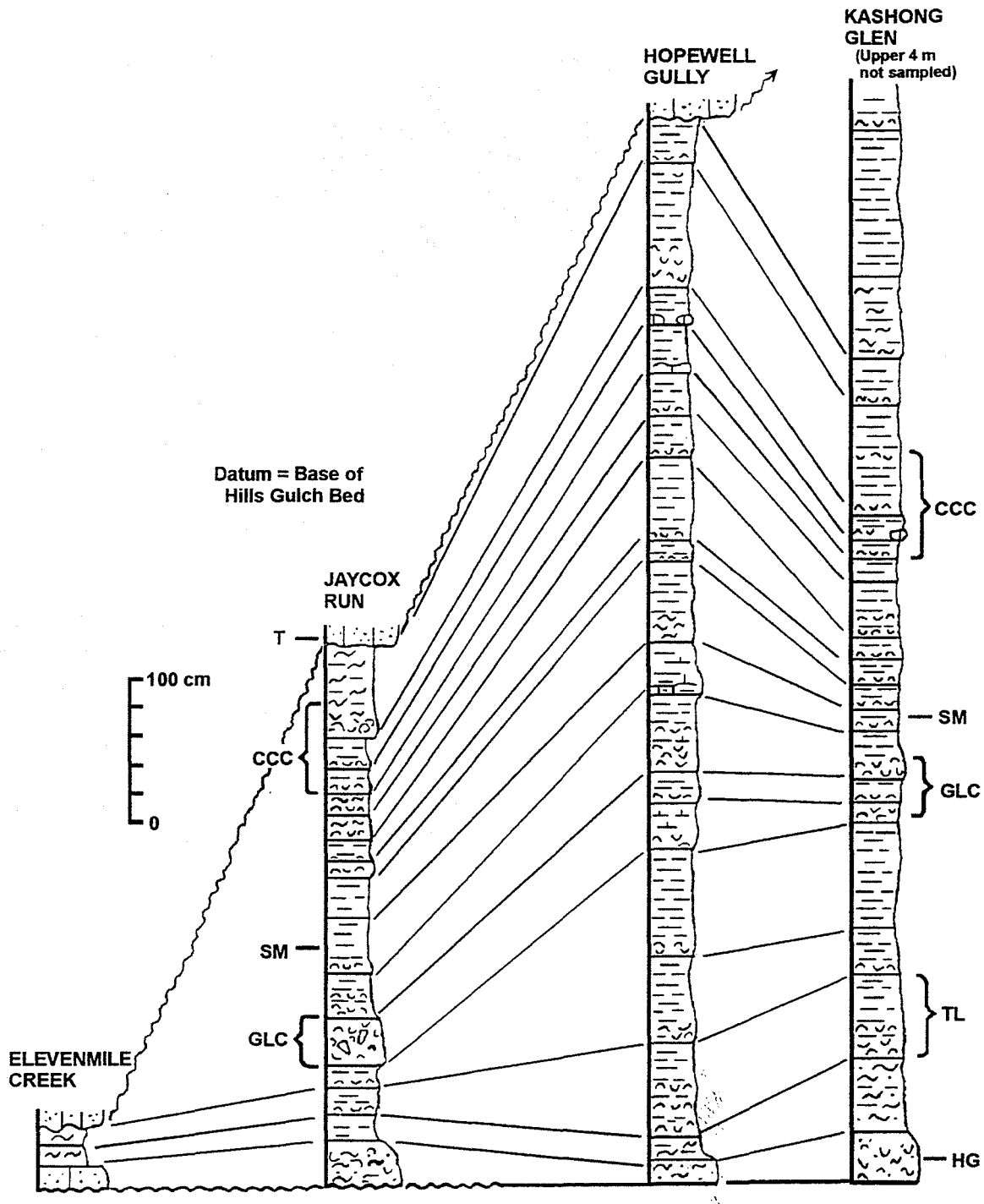
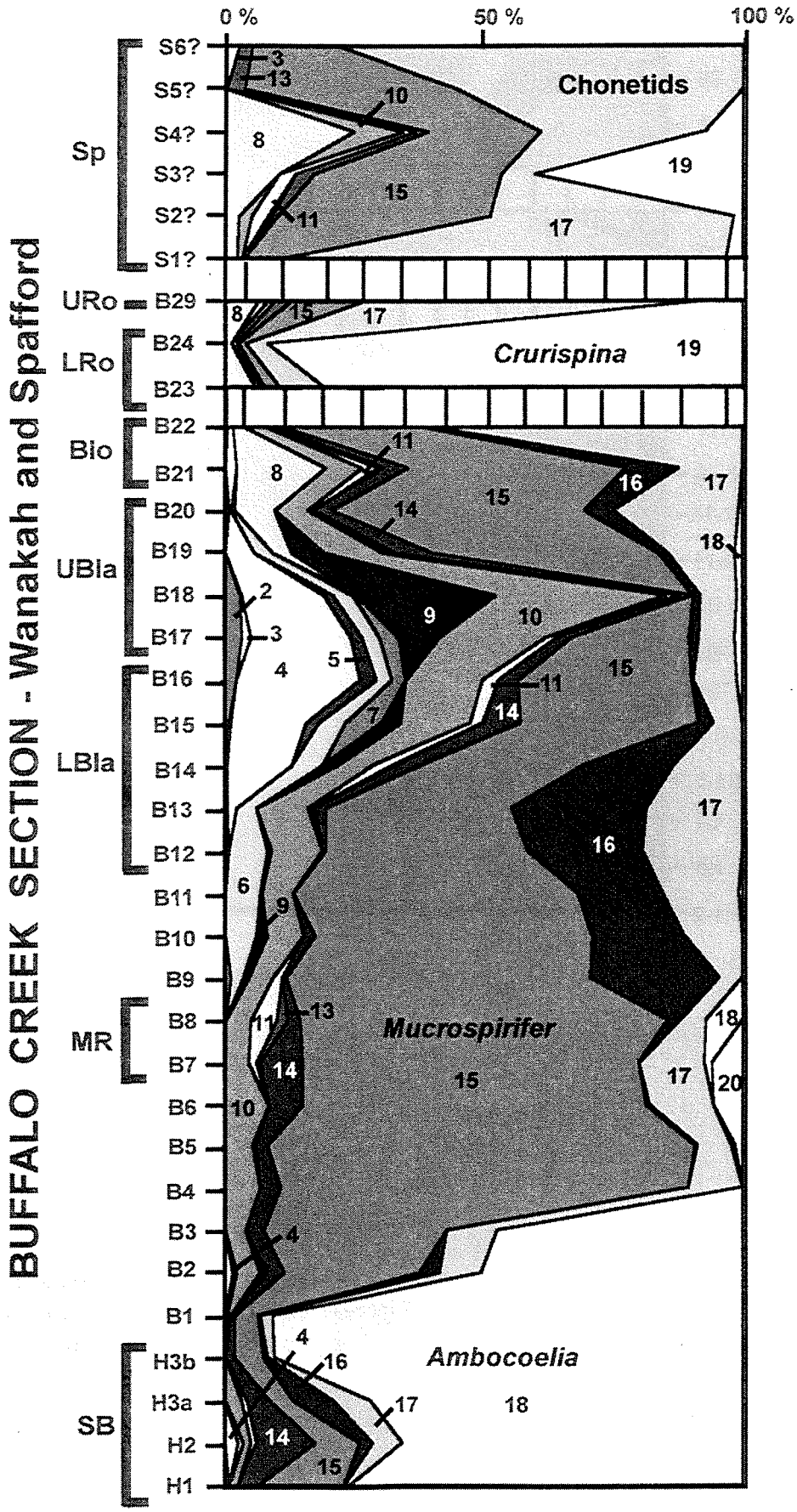


FIGURE 7. Correlation of measured sections through the Jaycox Member from Elevenmile Creek to Kashong Glen. Marker beds: HG Hills Gulch Bed; TL "*Tropidoleptus-Longispina* Bed"; GLC Greens Landing Coral Bed; SM "Sponge-*Megastrophia* Bed"; CCC Cottage City Coral Bed; T Tichenor Member.

FIGURE 9. Faunal frequency diagram for the Wanakah Shale and Spafford Member at Buffalo Creek. Additional bed prefix: S Spafford Member. Faunal categories and marker beds defined in Figure 8 caption, with additions: Ubla upper Blasdell Bed; Blo Bloomer Creek Bed; Lro lower Romulus Bed; Uro upper Romulus Bed; US upper Spafford Member. Lower gap represents maximum flooding surface at top of Bloomer Creek Bed; upper gap represents sub-Spafford unconformity.


BUFFALO CREEK SECTION - Wanakah and Spafford
0 %
50 %
100 %
Sp
URo
LRo
Bio
UBla
LBla
MR
SB
S6?
S5?
S4?
S3?
S2?
S1?
B29
B24
B23
B22
B21
B20
B19
B18
B17
B16
B15
B14
B13
B12
B11
B10
B9
B8
B7
B6
B5
B4
B3
B2
B1
H3b
H3a
H2
H1
Chonetids
Crurispina
Mucrospirifer
Ambocoelia

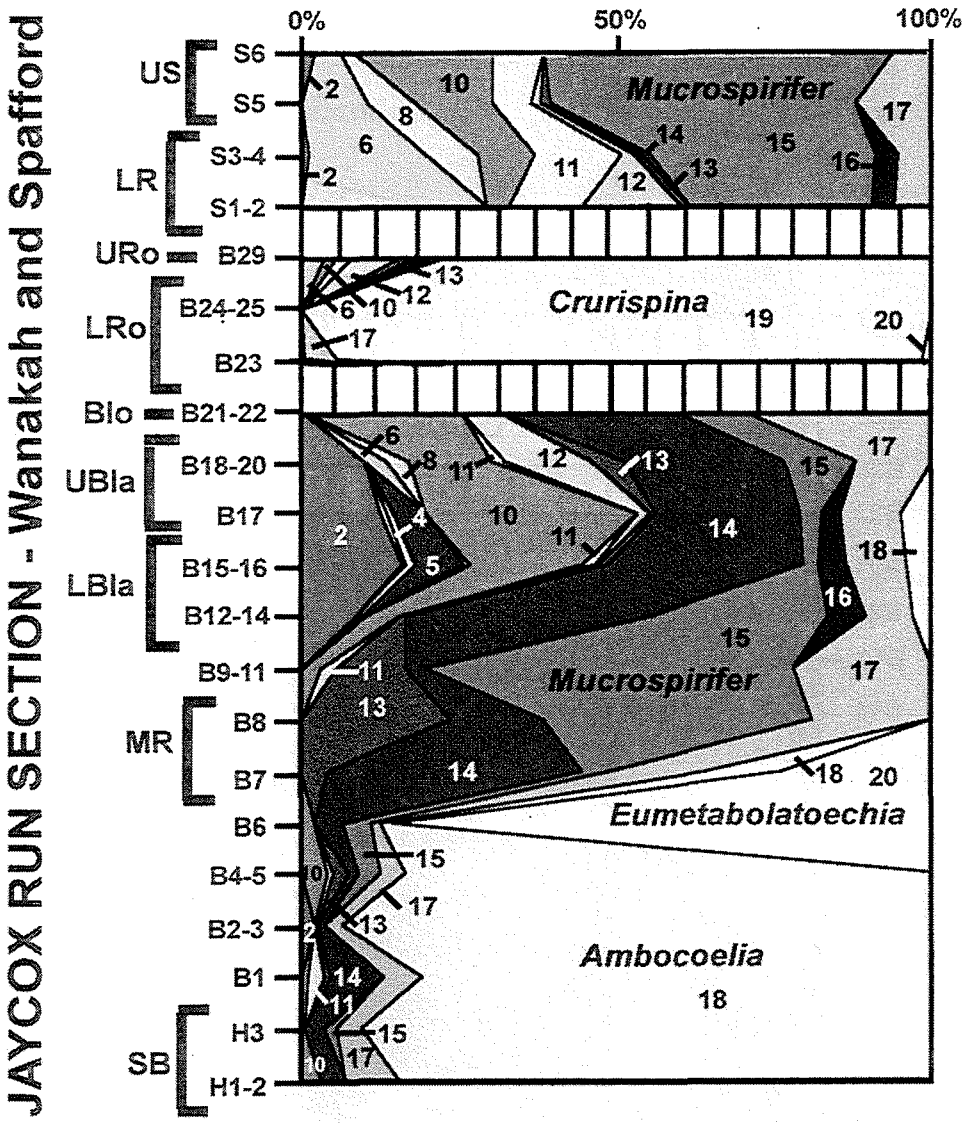


FIGURE 10. Faunal frequency diagram for the Wanakah Shale and Spafford Member at Jaycox Run. Faunal categories and marker beds defined in captions for Figures 8 and 9. Lower gap represents maximum flooding surface at top of Bloomer Creek Bed; upper gap represents sub-Spafford unconformity.

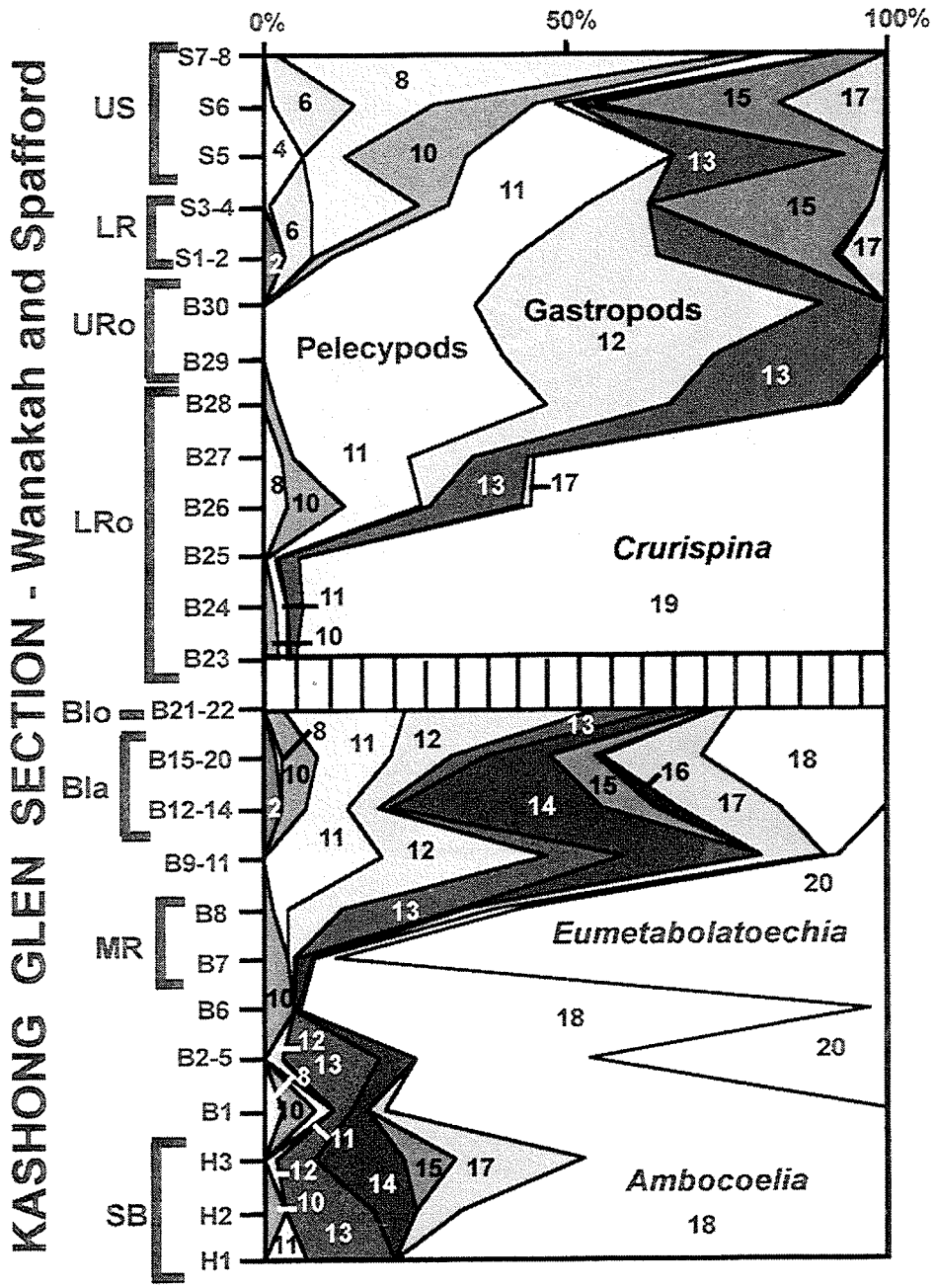


FIGURE 11. Faunal frequency diagram for the Wanakah Shale and Spafford Member at Kashong Glen. Faunal categories and marker beds defined in captions for Figures 8 and 9. Gap represents maximum flooding surface at top of Bloomer Creek Bed.

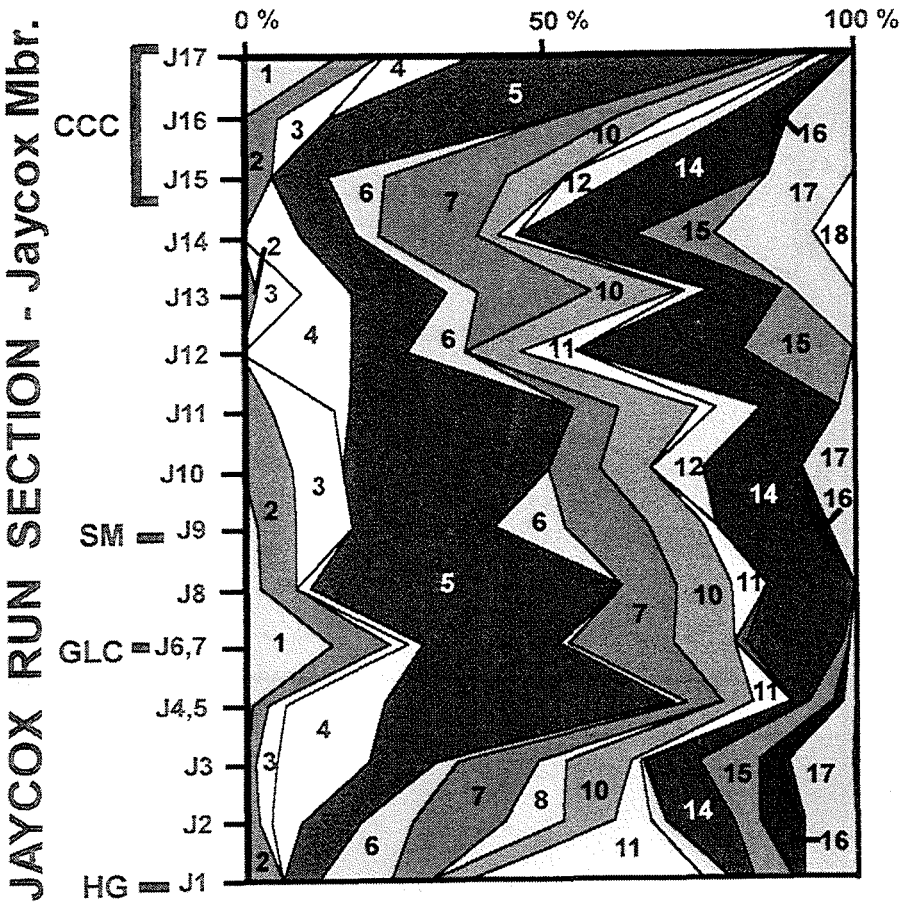


FIGURE 12. Faunal frequency diagram for the Jaycox Member at Jaycox Run. Faunal categories defined in Figure 8. Marker beds: HG Hills Gulch Bed; GLC Greens Landing Coral Bed; SM "Sponge-*Megastrophia* Bed"; CCC Cottage City Coral Bed.

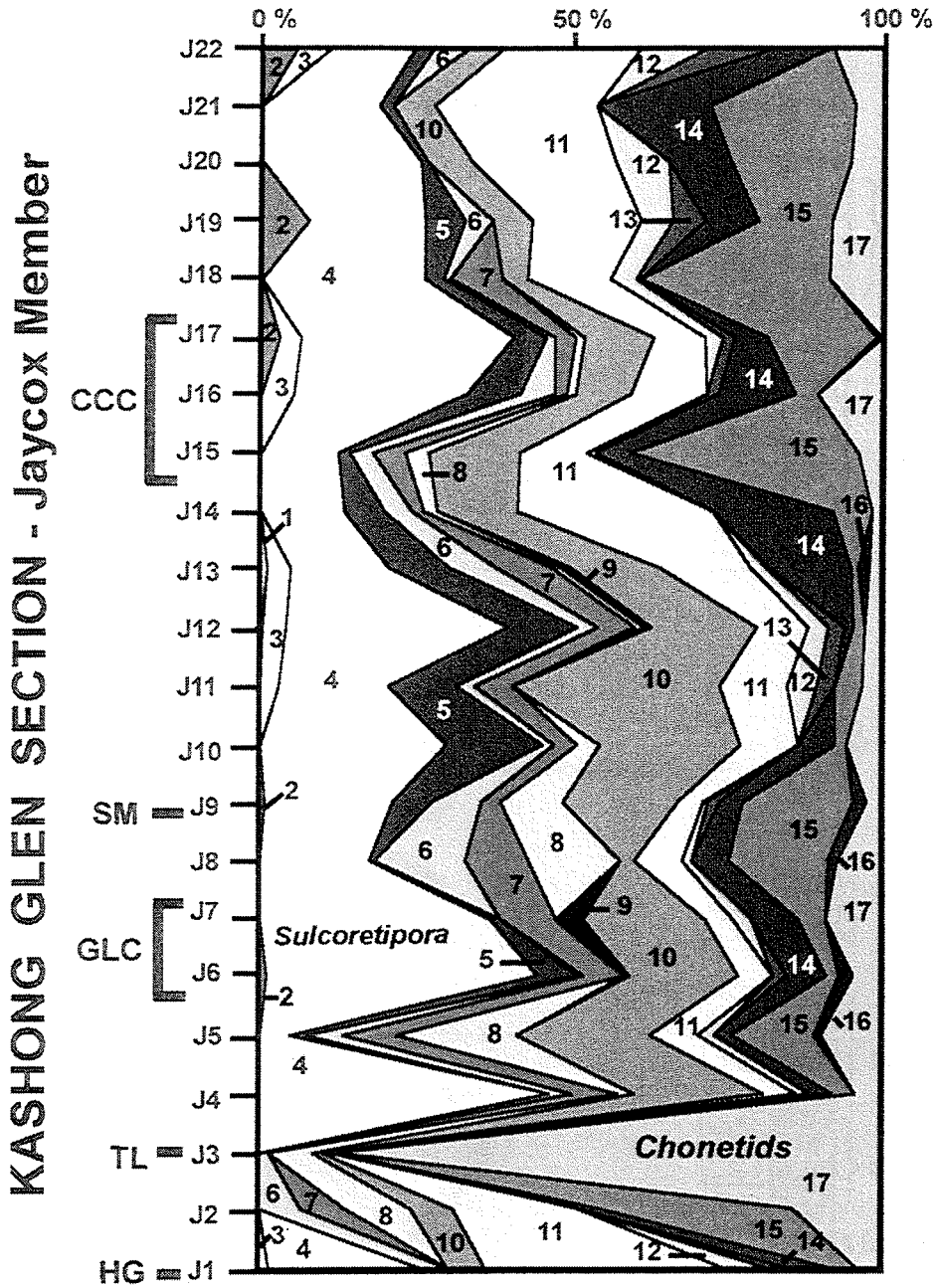


FIGURE 13. Faunal frequency diagram for the sampled portion of the Jaycox Member at Kashong Glen. Faunal categories defined in Figure 8. Marker beds defined in Figure 12 with addition: TL "*Tropidoleptus-Longispina* Bed".

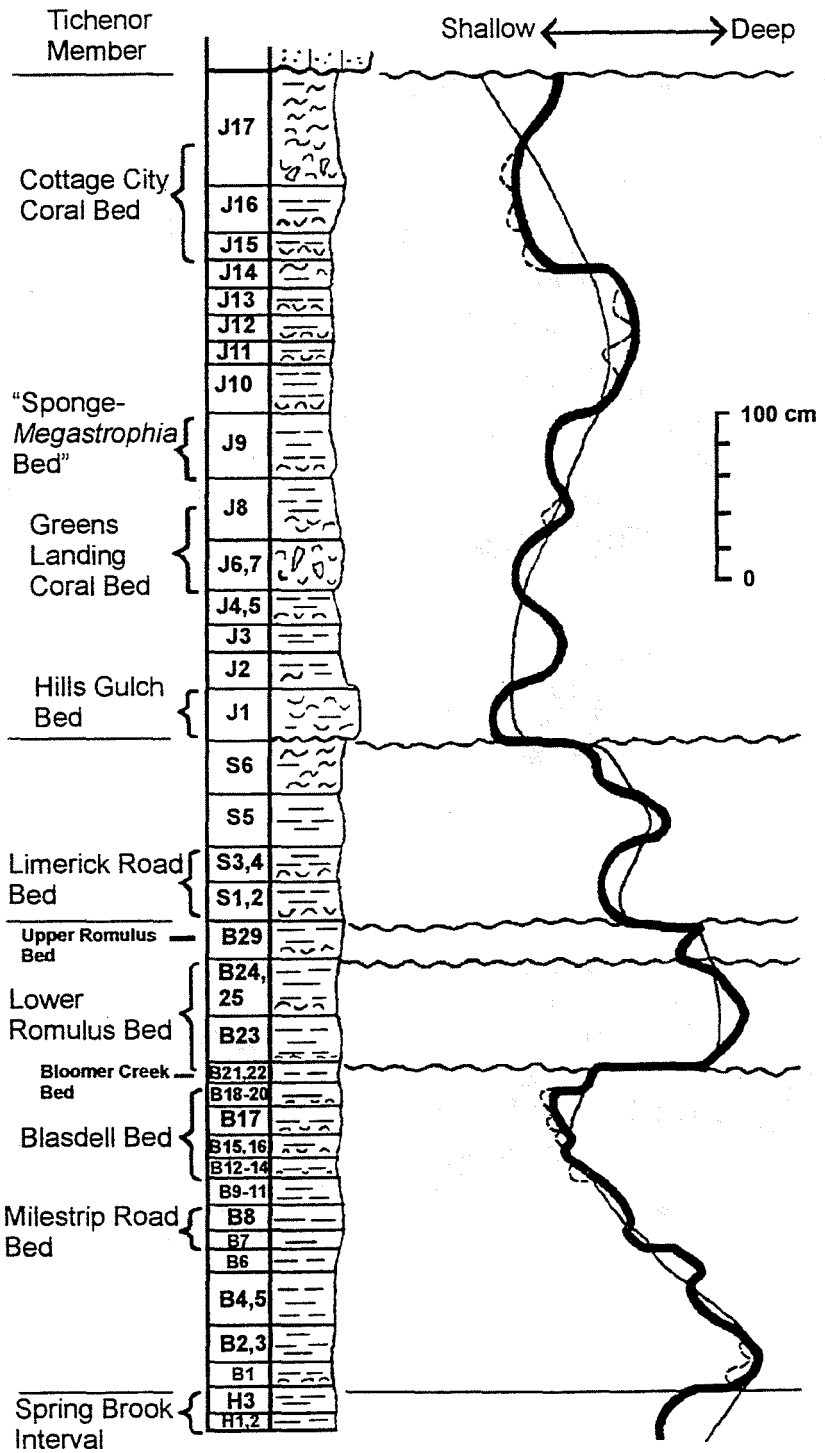


FIGURE 14. Study interval (Jaycox Run section) with interpreted sea level cyclicity shown at right. Three magnitudes of cycles are shown, superimposed on an overall shallowing trend.

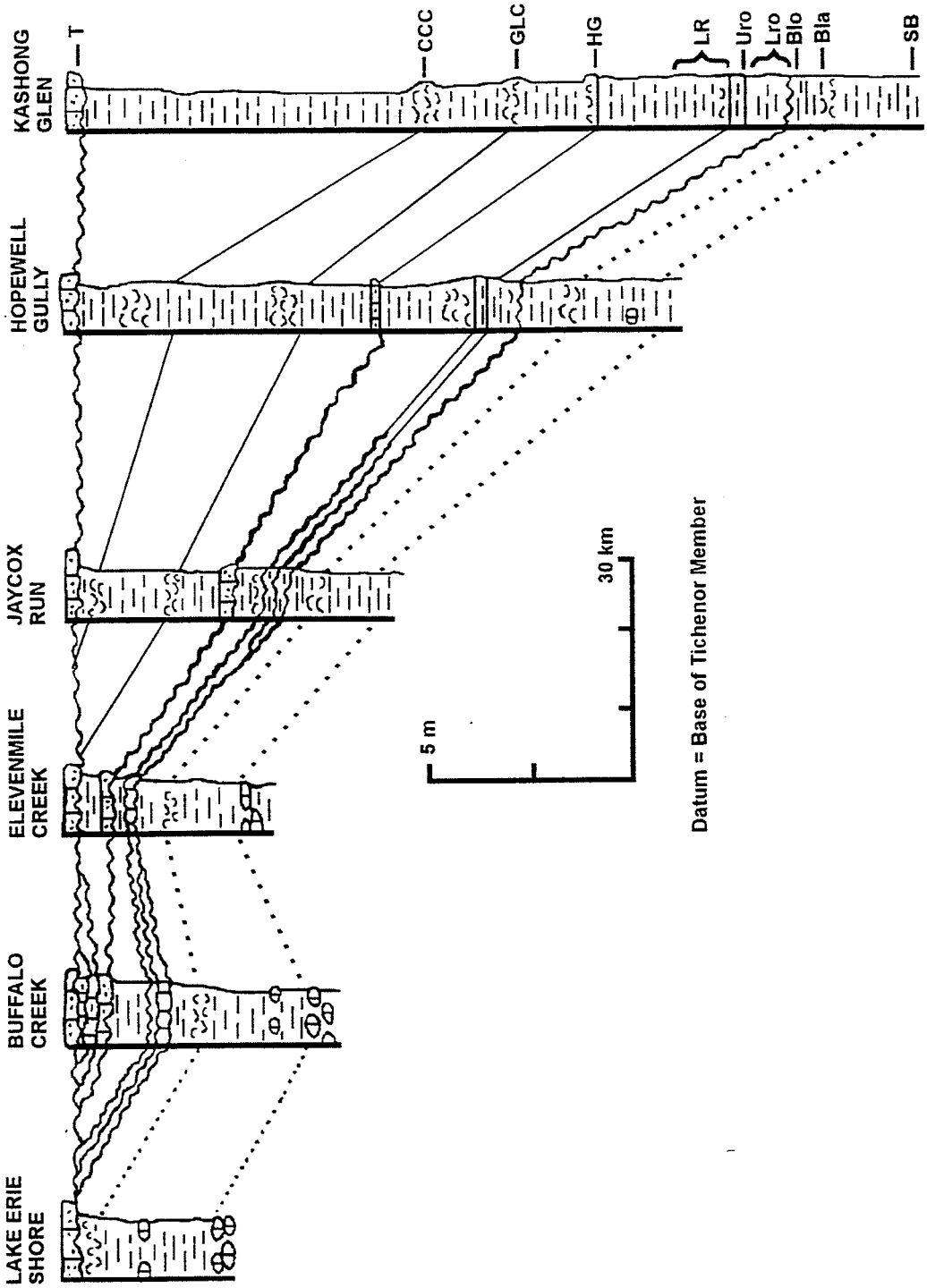


FIGURE 15. Correlation of study interval showing details of unconformities that merge westward to form a single sub-Tichenor unconformity at the Lake Erie shore. Marker beds: SB Spring Brook Interval; Bla Blasdell Bed; Blo Bloomer Creek Bed; Lro lower Romulus Bed; Uro upper Romulus Bed; LR Limerick Road Bed; HG Hills Gulch Bed; GLC Greens Landing Coral Bed; CCC Cottage City Coral Bed; T Tichenor Member.