EURYPTERID BIOFACIES OF THE SILURIAN-DEVONIAN EVAPORITE SEQUENCE: NIAGARA PENINSULA, ONTARIO, CANADA AND NEW YORK

Samuel J. Ciurca, Jr.
Rochester, New York 14621

For the past 28 years, I have been studying eurypterids, their stratigraphic occurrence, distribution, and associated flora and fauna, particularly in northeastern United States and Ontario, Canada. In New York the best known eurypterid assemblages are: 1) the *Eurypterus remipes* Fauna of the Fiddlers Green Formation that includes the earliest discovery of an eurypterid on this planet (by Dr. Mitchell in 1818); 2) the younger *Eurypterus lacustris* Fauna of the Williamsville Formation of western New York and Ontario, Canada; and 3) the eurypterid fauna of the Shawangunk Formation southeastern New York.

The search for new eurypterid faunas and the study of their geographic distribution in the Siluro-Devonian rocks of the region is important for several reasons. Foremost is the fact that the eurypterid faunas are punctuated within the known stratigraphic sequences. New genera appear suddenly within the sequences, e.g. *Waeringopterus Zone*, *Erieopterus Zone*, etc. When an eurypterid species disappears from the record completely, it is easily understood and we often assume extinction. The sudden appearance (or ecological replacement) of a species by an unrelated forms, (such as the Silurian *Eurypterus* being replaced by *Erieopterus* in the Early Devonian, is much more difficult to decipher. Only continued search for intervening occurrences, stratigraphically and geographically, will provide the data needed to understand the evolution of the eurypterids and their assemblages.

A second factor of significance concerns the eurypterid assemblages. Generally, where eurypterids are found there is a conspicuous absence of other fossils, in number and especially in diversity. Hence, the stratigraphic sequence is often considered to be unfossiliferous. The evaporite-bearing Salina Group is notable of this designation. Precise correlation, regionally and inter-regionally is needed to achieve a more complete understanding of these unique invertebrates. See Figure 1 for a map showing areas having exposures of Late Silurian-Early Devonian strata.

LOCKPORT GROUP

Eurypterids have only rarely been reported from the Lockport Group. Several reports in the literature are misidentifications, usually of the hard parts of other organisms, particularly phyllocarids.

Tylopterella boylei, reportedly from the Guelph Formation near Elora, Ontario, is the only fully known eurypterid from the Lockport Group of Canada. See Clarke and Ruedemann (1912, p. 216) for a full description.

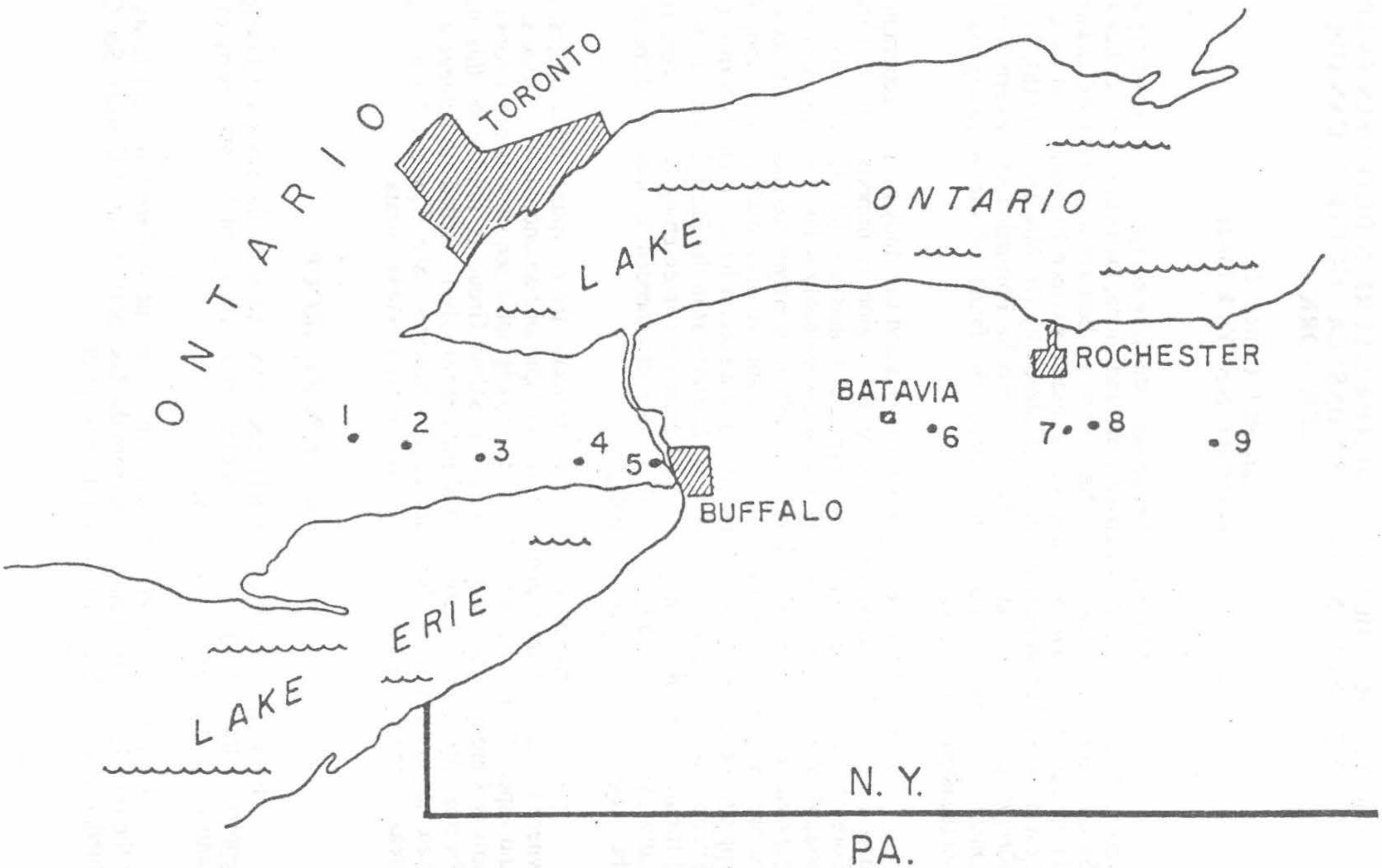


Figure 1. Areas (1-9) have exposures of Late Silurian-Early Devonian strata:
1) Haggersville 2) Cayuga 3) Dunnville 4) Port Colburne 5) Fort Erie
6) LeRoy 7) Honeoye Falls 8) East Victor 9) Phelps

(From Ciurca, 1982)

Eurypterus logani (Williams, 1915) is not an eurypterid. An examination of his plates reveals that all of the structures illustrated pertain to a phyllocarid (Ciurca, 1989). The specimens are tentatively referred to *?Ceratiocaris logani*. This is further supported by the discovery of many additional phyllocarid remains at numerous sites from the Niagara River on the Ontario side, westward to the Eramosa River.

It is not surprising that few eurypterid remains have been reported from typical Lockport facies. The lower Lockport Group could be termed a coral-stromatoporoid phase (Decew/Gasport/Goat Island) and eurypterids are not usually found in the various facies associated with these forms.

Much of the Lockport Group, however, belongs to the stromatolite phase and it is expected that eurypterid remains would be associated with some of the facies accompanying stromatolite development. This interpretation is based on occurrences of eurypterid faunas in the Bertie and Manlius Groups (Ciurca, 1978; 1990, this paper).

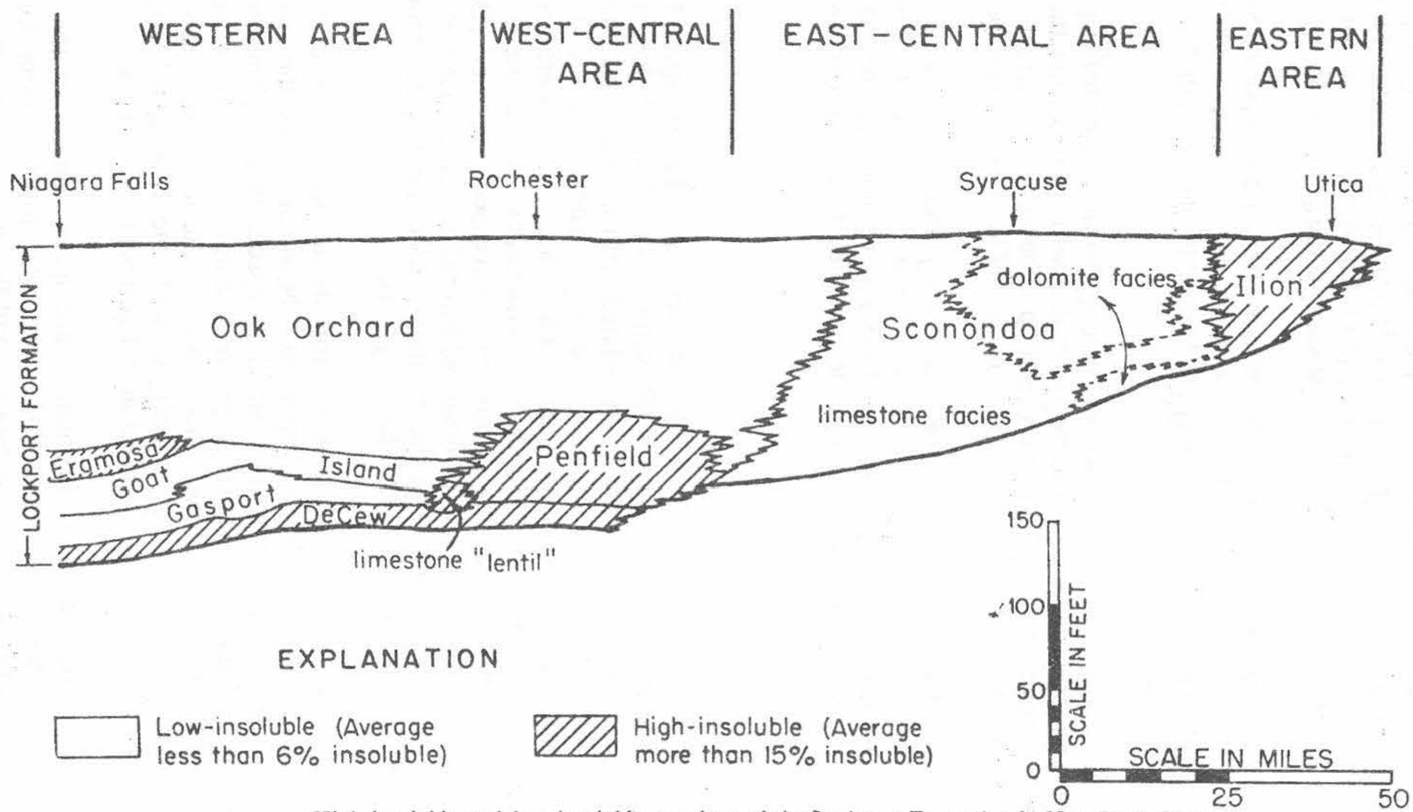
The following discussion utilizes the stratigraphy and nomenclature of Zenger (1965) shown in Figure 2. Work in progress by Brett and associates (at University of Rochester) will undoubtedly lead to a revision of Lockport nomenclature and the eurypterid occurrences discussed below will have to be modified to correspond with the new stratigraphic interpretations.

ILLION FORMATION

Clarke and Ruedemann (1912, p. 420) described a peculiar eurypterid from eastern New York, *Rhinocarcinosoma vaningeni*. Specimens were found below the red Vernon Shale in a large "concretionary block" associated with *Lingula* and *Orbiculoidea*. The "concretionary block" is now recognized as a large stromatolite and it is obvious that *Rhinocarcinosoma* lived in an environment in which black muds were accumulating among and behind stromatolitic or thrombolitic biostromes. Since the original discovery, no further specimens pertaining to this genus have been reported. Dale (1953) made an extensive search, but failed to locate additional material. Zenger (1965, p. 104) failed to find eurypterid remains at the Farmers Mills Site but did report telsons and scalelike markings that may pertain to this eurypterid.

I have located *Rhinocarcinosoma* in a stromatolite bed at Moyer Creek, but remains are exceedingly scarce. More important, however, was the discovery of another eurypterid in the Illion Formation. Small carapaces of a hughmilleriid, probably *Parahughmilleria* (Kjellesvig-Waering, personal communication), were found at Farmers Mills and also at Moyer Creek. This small eurypterid is easily recognized by its semicircular carapace and cannot be confused with the "common" *Hughmilleria socialis* so well known from the Pittsford Bed near Rochester, New York.

The dark shales of the Illion Formation are quite similar to the "Pittsford Facies" originally described by Sarle (1903) from the lower Salina Group near Rochester, New York. Large stromatolitic mounds and thrombolite horizons are intercalated with the otherwise mudstone and shale that constitute most of the Illion Formation.



High-insoluble and low-insoluble members of the Lockport Formation in New York State.

Figure 2. Stratigraphy of the Lockport Group (from Zenger, 1965)

Spectacularly, the upper Illion Formation, transitional to the overlying Vernon Formation, harbors a rich eurypterid fauna identical to the lithofacies and biofacies described for the eurypterid beds in the type region of the Pittsford Bed (see Sarle, 1903 and Ciurca, 1985a).

Ciurca (1986a) has termed the new eurypterid bed the Farmers Mills Bed for the occurrence along Oriskany Creek at Farmers Mills, ironically the locality which provided the first *Rhinocarcinosoma* remains described by Clarke and Ruedemann (1912), and has transferred the unit to the Salina Group based on lithological characteristics. This reassignment may help us to realize that the eurypterid-bearing black shales of the Salina Group are facies of portions of the Lockport Group. Zenger (1965) has already suggested a similar relationship for the Clinton and Lockport Groups in the region.

It may be that the entire Illion Formation should be included in the Salina Group. It is known that the Illion Formation interfingers with the Sconondoa Formation to the west, supporting the thesis that the eurypterid beds of the east are correlative with the beds westward that are lithologically part of the Lockport Group. There is also paleontological support for this. (see discussion of the Sconondoa and Oak Orchard Formations).

SCONONDOA FORMATION

Zenger (1962; 1965, p. 88-89) described the Sconondoa Formation of central-eastern New York as "brownish grey to dark grey, aphanitic, thin to medium-bedded and bituminous" limestone. Zenger noted that stromatolites and associated edgewise conglomerates are abundant east of Baldwinsville, especially at Sconondoa Creek in the Oneida Quadrangle.

At the Sodus Quarry, about 70 miles west of Sconondoa Creek, a similar facies in the floor of the north quarry was discovered (Ciurca and Domagala, 1988). This horizon apparently was not exposed at the time Zenger studied this section (Zenger's Locality No. 17).

A stromatolite horizon occurs near the base of the section, with over 60 feet of "Oak Orchard" above. The stromatolite zone may actually consist of four separate horizons with intercalated ripplemarked black shales and dolomitic beds.

Below the stromatolite beds are variable beds which could best be described as the *Chondrites* facies. The beds consist of fine-grained limestone with conchoidal fracture, apparently argillaceous limestone with sparry interlayers bearing an interesting fauna of brachiopods, gastropods (some unusually large), cephalopods, ostracods and trilobites. The most exciting find was an eurypterid which corresponds to the *Rhinocarcinosoma vaningeni* of the eastern facies, ie. Illion Formation. If this analysis is correct, the occurrence at the Sodus Quarry extends the known geographic distribution of *Rhinocarcinosoma* substantially. This unusual eurypterid was also recently discovered in the McKenzie Formation in Pennsylvania (Ciurca, 1978) in a facies not unlike that of the Sconondoa and Illion Formations of central-eastern New York.

Currently, the exact relationship of the Sodus Quarry eurypterid/stromatolite horizons to those farther east is unknown. I suspect we will find that stromatolitic beds occur still lower in the section in an eastward direction.

OAK ORCHARD FORMATION

Most of the Lockport Group in western New York consists of massive dolostones, some biostromal and vuggy (mineraliferous) units of thin and medium bedded, fine to coarse-grained dolostone and much of this is described as bituminous. Crystalline vugs are common and different horizons or beds carry distinct mineral suites (see Ciurca, 1989; 1990).

The uppermost Lockport Group at Rochester, eg. the beds at Allens Creek at New York Route 65, consists of fine-grained thin and medium-bedded dolostone containing a small fauna; *Howellella*, pelecypods and eurypterids, chiefly *Eurypterus pittsfordensis*. Interbeds consist of low stromatolitic mounds and oolitic beds with occasional *Favosites*. Intraformational conglomerates are present and are undoubtedly associated with the algal phase. Such conglomeratic horizons are common in the Illion Formation to the east and in the algal phase in the Bertie and Manlius Groups.

Re-excavation of uppermost Lockport rocks during July of 1989 at the eurypterid site at North Chili (NY 33 and 259) has provided additional data on the occurrence of *Eurypterus pittsfordensis*. The lithologies present are more indicative of the Lockport Group than of the Salina Group, but the sequence is still best described as transitional. There is little indication of the greenish shales so typical of parts of the Salina Group at the eurypterid sites near Pittsford, New York and no red shale is present. Much of the rock is dolomitic, some resistant and more typical of Lockport lithologies, and some is dolomitic mudstone that weathers more readily. *Eurypterus pittsfordensis* is common along with *Lingula* and pelecypods. *Chondrites* is very important here and, like the occurrence at the Sodus Quarry (see Sconondoa Fm.), this section can best be described as belonging to the *Chondrites* facies. Three large algal mounds were observed and two of these were recovered (one has been presented to the Buffalo Museum of Science). The North Chili Site represents the most westward occurrence of *Eurypterus pittsfordensis* currently known (Ciurca, 1990, in press).

Along the Niagara River a portion of an eurypterid was discovered in uppermost Lockport rocks or transitional Salina beds (Ciurca, 1989). The most likely source is the interval described by Zenger (1965, Loc. 7, p. 167) at the Intake Towers of the Niagara Power Project. Unfortunately, the uppermost Lockport Group is not exposed anywhere in the region and only future excavations and cores can provide data for this interval.

As increasingly observed for the facies, the Niagara Falls eurypterid is associated with a sequence bearing numerous stromatolite horizons and possible salt hoppers. The large-scale stromatolites described by Zenger (1965, p. 114, Fig. 22) are still visible at several points along the Niagara River Gorge. An analogous occurrence in Ohio is worth mentioning. At the Maumee Quarry east of Toledo, favositid "reefs" are overlain by stromatolites before giving way to the overlying Greenfield Formation. Within this stromatolitic sequence occurs *Paracarcinosoma*, a genus prominently known from the Williamsville Waterlime at Buffalo, New York. This is the first eurypterid to be reported from this quarry (Ciurca, in preparation).

SALINA GROUP

The Salina Group represents an extraordinary sequence of red beds, fine-grained limestone and dolostones and extensive beds of evaporites, mostly anhydrite/gypsum and halite. Though generally unfossiliferous, certain beds within the group have provided faunas rich in eurypterids and other peculiar forms. Recent efforts have been directed at identifying more precisely the known eurypterid horizons and at locating additional horizons not only within the Salina Group of New York, but also within the wonderful stratigraphic sequences displayed in Ontario, Canada, Pennsylvania and other parts of the Appalachian Basin.

The following discussion is limited to recent observations of the stratigraphic position and geographic distribution of eurypterid horizons in the Salina facies. Much of the Salina Group in New York is detrital, and the eurypterid biofacies possibly reflect, at least in part, faunas differing from those typical of the Bertie Group that overlies this sequence.

VERNON FORMATION

The type section for the Vernon Formation is at Vernon, New York. (See Alling (1928, p. 23) for a vivid description of the Vernon and its relation to the salt beds. Most of the Vernon is red shale and mudstone. However, several other lithofacies are present: green and black shales, resistant waterlimes, thin dolostone beds, evaporites, and even sandstones (presumably tongues of the Bloomsburg Formation of Pennsylvania or the Shawangunk Formation of southeastern New York.

In thin (0.25m-1.0m) green, black and greenish-black beds, mostly within the lower Vernon Formation, occur a variety of eurypterids, other arthropods (*Pseudoniscus*, phyllocarids) and usually *Lingula*, cephalopods, pelecypods, and, rarely, brachiopods. Most of the eurypterid-bearing units currently known are located in the Rochester, New York area, the type area for the"Pittsford Shale" of Sarle (1903). The following beds have recently been proposed but are not described below in stratigraphic order.

Pittsford Bed

Type Locality: Covered sequence behind and near the Spring House, Monroe Avenue, Pittsford, New York.

When Sarle described the "Pittsford Shale" and its fauna, the unit (reasonably) included the eurypterid beds and all the strata below to the contact with the Lockport dolostones. Fisher (1960) and Rickard (1975) thought that the Pittsford was simply a local facies of the Vernon Formation and suggested the unit be abandoned. Ciurca (1985a), in contrast, suggested that, even though of possible limited extent (not much is known about the Lockport/Vernon contact throughout its extent), the "Pittsford Shale" was a lithologic unit bearing an exceptional eurypterid-bearing interval and that the unit be termed the Pittsford Bed. Supporting this was the recognition, in the region, of other distinct eurypterid-bearing horizons separate from the type Pittsford Bed by other lithofacies, mostly red and green shales and mudstones. The Pittsford Bed, thoroughly described by Sarle, bears *Hughmilleria socialis* in enormous numbers. Also present are *Eurypterus pittsfordensis*, *Pterygotus monroensis* and many other species.

My observations of the Pittsford Bed, exposed during excavations for an enlarged Wegmans/Chase-Pitkins plaza and other nearby projects, indicate that the depositional site dried up (subjected to subaerial exposure) leaving a mudcracked interval before the deposition of overlying waterlimes, shales and mudstones. The Pittsford Bed provides the best impression of eurypterids being trapped in an evaporating body of water. Nothing, of course, is known about their potential for surviving dry spells analogously to many modern forms, especially fish, that survive by burying themselves in the muds until the next inundation. While salinity may have been high during deposition of the Pittsford Bed, the evidence has not been observed in this unit as it has in the stratigraphically higher Barge Canal Bed (see Ciurca, 1985b).

Barge Canal Bed

Type Section: Barge Canal just west of village of Pittsford, N.Y.

The Barge Canal Bed (Ciurca, 1985b) was named for the black shale described by Ruedemann (1919) and containing predominately the *Eurypterus pittsfordensis* Fauna. The outcrop in the Barge Canal was rediscovered by the author during exploration for available exposures of the Vernon Formation in the region. The Barge Canal Bed is still exposed when the canal is drained during winter, and consists of black shale grading upward into more greenish to bluish-weathering shale. In this unit, well developed salt hoppers were observed for the first time this low in the Salina Group, and suggest that all of the eurypterid horizons experienced salinity crises.

This stratigraphic position in the area is easily established, but the exact thickness of Salina beds occurring between the Pittsford Bed below, and the Barge Canal Bed above, is unknown. About 20 feet of strata were observed overlying the Pittsford Bed at the I-590 Site with no evidence of the Barge Canal Bed. Thus the intervening beds are over 20 feet in thickness and probably less than 60 feet. The most important faunal element of the Barge Canal Bed is *Eurypterus pittsfordensis*. *Hughmilleria socialis* appears to be excluded. Rare *Mixopterus* remains have been found, however the geographic extent of the Barge Canal Bed is unknown. I have suggested that the Gananda Site (Hamell, 1978) probably is equivalent (Ciurca, 1984).

Monroeav Bed

Type locality: I-590 just south of Monroe Avenue, Rochester, New York.

The discovery of an even lower eurypterid bed, i.e. relative to the Pittsford Bed, prompted the redefinition of Sarle's "Pittsford Shale", and the naming of newly discovered and previously described eurypterid-bearing units (Ciurca, 1984).

About 15 feet below the Pittsford Bed occurs about 7 feet of greenish dolomitic shale and mudstone replete with *Lingula*. The interval corresponds to the 7 feet of section described in Clarke and Ruedemann (1912, p. 103). To this shaly interval I have given the name Monroeav Bed (Monroe Avenue). While the lower contact was not observed, it seems likely that the Monroeav Bed rests directly upon the Lockport Group.

Eurypterus pittsfordensis is the only eurypterid obtained from this unit. No correlatives are known, but the North Chili Site may be a possible correlative, even though the facies at North Chili appears to be more Lockport-like in dolomitic character. The Monroeav, Pittsford, and Barge Canal Beds are all located within a small geographic area at Pittsford, New York, and their relative position is easily determined. See description of Harris Hill Bed that follows for additional comments.

Harris Hill Bed

Type Section: Wegmans parking lot, south side of NY 441, south of Harris Hill, East Penfield.

North and east of the type Pittsford Bed, another eurypterid occurrence was found that appears not to be related to the previously described units. Temporary excavation for construction of Wegmans Supermarket revealed a thin section of fine-grained dolostones, red, green, and black shales. For the thin (about 0.3m) black shale I have proposed the name Harris Hill Bed (1985b). The Harris Hill Bed contains abundant *Hughmilleria socialis* and rare *Pterygotus*, and *Mixopterus*.

The Harris Hill Bed is the thinnest of the beds described and it is possible that it is simply the thinned equivalent of one of the previously described beds. However, if the inclination of the bedrock in the area is relatively normal, calculations indicate the possibility the Harris Hill Bed is even lower, stratigraphically, than the Monroeav Bed. The Vernon red beds thicken dramatically eastward (about 600 feet at Syracuse) and it is possible that some of this increase in thickness is picked up at its base (see Figure 3). Still higher eurypterid occurrences within the Vernon Formation compound the problem of age relationships between the various eurypterid horizons.

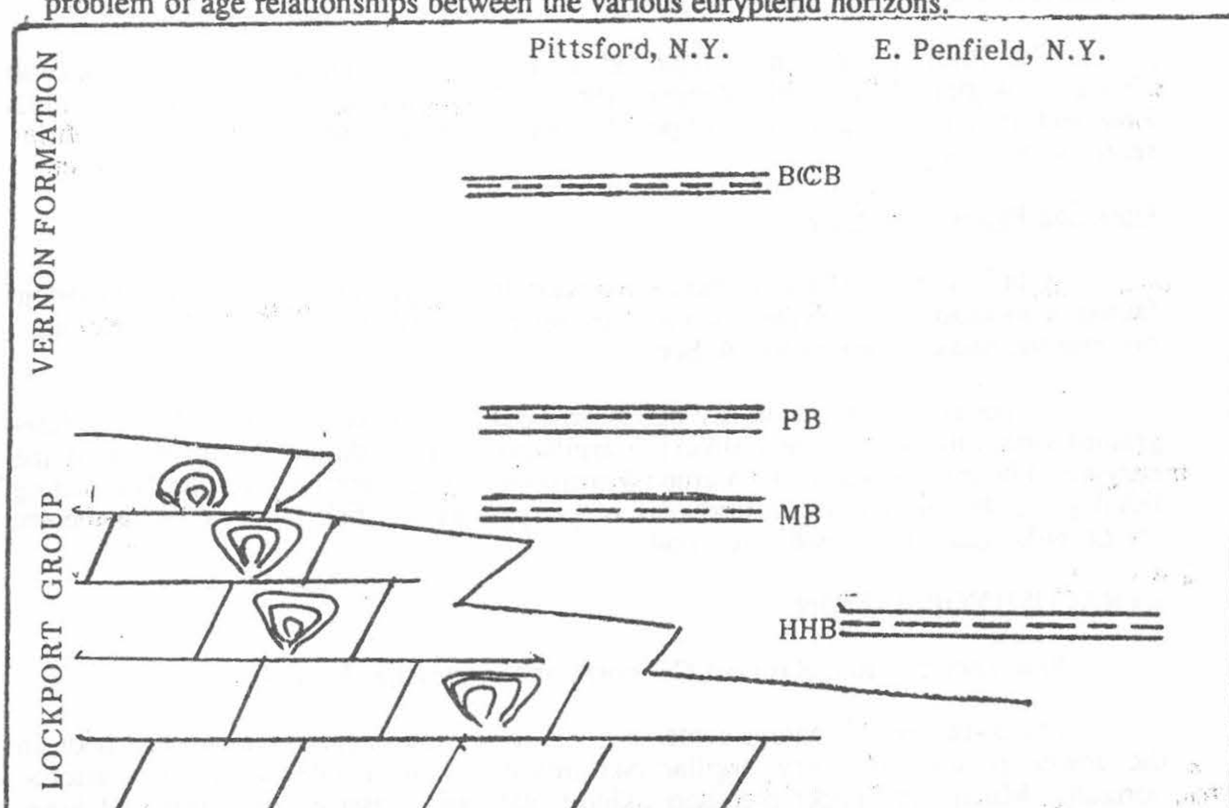


Figure 3. Eurypertid-bearing black shale horizons: possible relationship to the Lockport Group Below. HHB = Harris Hill Bed, MB = Monroeav Bed, PB = Pittsford Bed, BCB = Barge Canal Bed.

Farmers Mills Bed

Type Section: Oriskany Creek and tributary at Farmers Mills.

In eastern New York the Illion Shale underlies the Vernon Formation. Transitional shales have been described as Farmers Mills Bed by Ciurca (1986a). This portion of the Illion Formation has been assigned to the Salina Group on lithological grounds. The Farmers Mills Bed is about one meter thick and consists of greenish and black fissile shale lithofacies so well-known from the lower Salina beds at Pittsford, New York.

Thus far, *Rhinocarcinosoma vaningeni*, described from the Illion Shale proper, has not been recognized in the Farmers Mills Bed. Other eurypterids, however, are abundant as they are in the type Pittsford Bed of western New York. The following animals have been found in the type Farmers Mills Bed: *Hughmilleria*, *Pterygotus*, *Parahughmilleria*, *Mixopterus*(?), and *Lingula*.

Correlation of the Farmers Mills Bed is currently impossible on the basis of the eurypterids alone. Microfossils, however, may provide a basis for comparison with the eurypterid horizons of western New York. The Farmers Mills Bed is currently recognized in the area between Clinton and Frankfort, New York. The occurrence at the latter locality (Moyer Creek) represents the easternmost point from which eurypterid remains are known from the Salina Group.

The Illion Formation is regarded as the eastern equivalent of the Lockport Group of western New York (Zenger, 1965). The stratigraphy of the Farmers Mills Bed, and its relationship to the Lockport-Vernon sequence in western New York, is currently under study.

Downing Brook Bed (New)

A thin interval of the Vernon Formation in the type area contains an important faunal association of eurypterids and fish remains (Fisher, 1957). For this unit I propose the name Downing Brook Bed.

Unlike all of the previously described beds, the Downing Brook Bed is a fine-grained dolomitic unit quite unlike the argillaceous units that make up most of the eurypterid-bearing strata of the Vernon Formation. Consequently, with the contrasting lithologies, the fauna consists primarily of pterygotids and fish remains. Also present are *Lingula*, gastropods, and pelecypods.

SYRACUSE FORMATION

Reference Section: Railroad Cut north of Fayatteville, New York.

The Syracuse Formation contains a variety of lithologies. Transitional beds in the lower portion are very argillaceous dolostones with intercalated stromatolite horizons. Middle and upper members exhibit platy and massive dolostones and limestones. Evaporite features are common, including cavities formed by the dissolution of gypsum and halite. See Leutze (1956, 1961, 1964) for a complete discussion of the Syracuse Formation in central-eastern New York.

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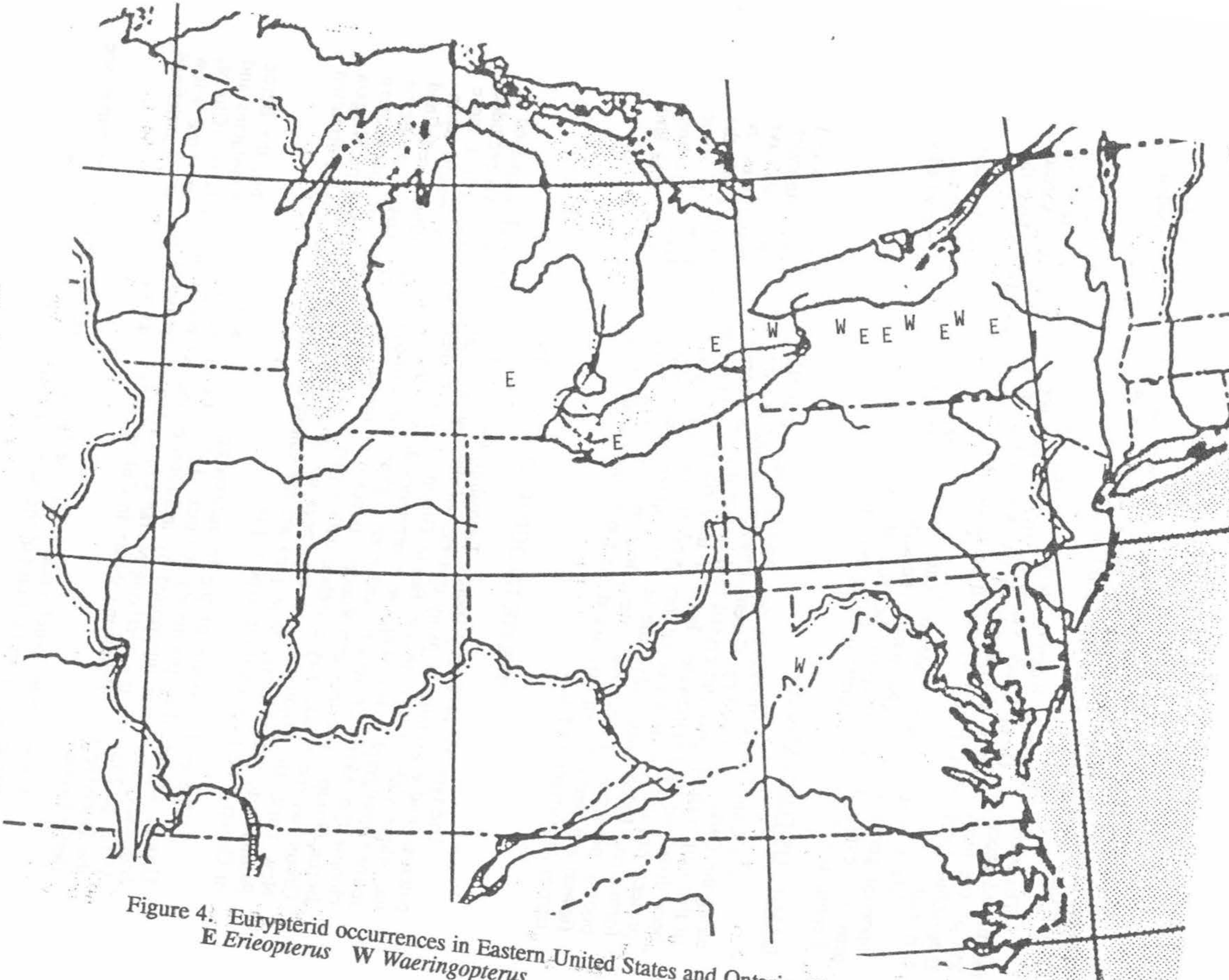

Figure 4. Eurypterid occurrences in Eastern United States and Ontario, Canada.
E *Erieopterus* W *Waeringopterus*

In western New York, the Syracuse Formation was traced from the Clyde River westward through the Oatka Creek Valley, Black Creek east of Batavia, I-990 roadcut (gypsiferous) into Ontario, Canada (Welland Canal Site).

The zonal eurypterid, *Waeringopterus*, was recovered from all of the localities mentioned except the Oatka Creek Valley (Ciurca, in preparation). *Waeringopterus* is one of the most common eurypterids in the Appalachian Basin and its widespread geographic distribution (Figure 4) should be useful in correlating strata throughout the northeast.

Many attempts were made to locate *Waeringopterus* in Pennsylvania, but this important genus has yet to be found. The section near Mt. Union, which has already provided several distinct eurypterid horizons at one locality, is a most likely site worthy of continued effort and is currently being examined.

CAMILLUS FORMATION

The Camillus Formation is most readily observed at NY 19 north of LeRoy and along the Oatka Creek Valley. Greenish mudstones and dolomitic shale constitute much of this unit. Salt hoppers and crystal cavities are present where evaporite minerals have been dissolved by groundwater. Beds of anhydrite/gypsum are known. Waterlimes are present, but little is known about their stratigraphic position and distribution within the formation. Paleontologically, the unit is impoverished. Ostracods and perhaps some poorly preserved pelecypods are uncommon at best. The Fort Hill Waterlime (lowermost Bertie Group) occurs at the top of the Camillus in western New York and carries an *Eurypterus* fauna.

BERTIE GROUP (REDEFINITION)

The type Bertie Group (Bertie Township, Ontario, Canada) is well displayed at outcrops and especially in many quarries of the region. Many authors have excluded the Akron-Cobleskill from the Bertie Group, but it is here suggested that a more refined stratigraphy, revealing the interrelationships of the various units, results by including the Akron-Cobleskill, and even higher undescribed units, within a redefined Bertie Group. Note the term Rondout is not used herein. While portions of the Bertie Group, as redefined, may correlate with a part or all of the Rondout of southeastern New York, the lithologies and sequences we observe in the region from the Niagara Peninsula to near Albany, New York are not equivalent. The term Rondout Formation or Group is best utilized in its type region.

The cyclic nature of the formations and members included within the Bertie Group, as described previously (Ciurca, 1973; 1978), ie. recurring lithofacies and biofacies, are better interpreted by inclusion of the Akron-Cobleskill facies (Ciurca, 1978, p. 233) and the overlying Moran Corner Waterlime (unnamed waterlime below the Honeoye Falls Dolostone shown in Ciurca, 1978, Figures 2-3) within a redefined Bertie Group.

The suggested redefinition shows the Moran Corner Waterlime (new name, see this paper) as the uppermost unit of the Bertie Group.

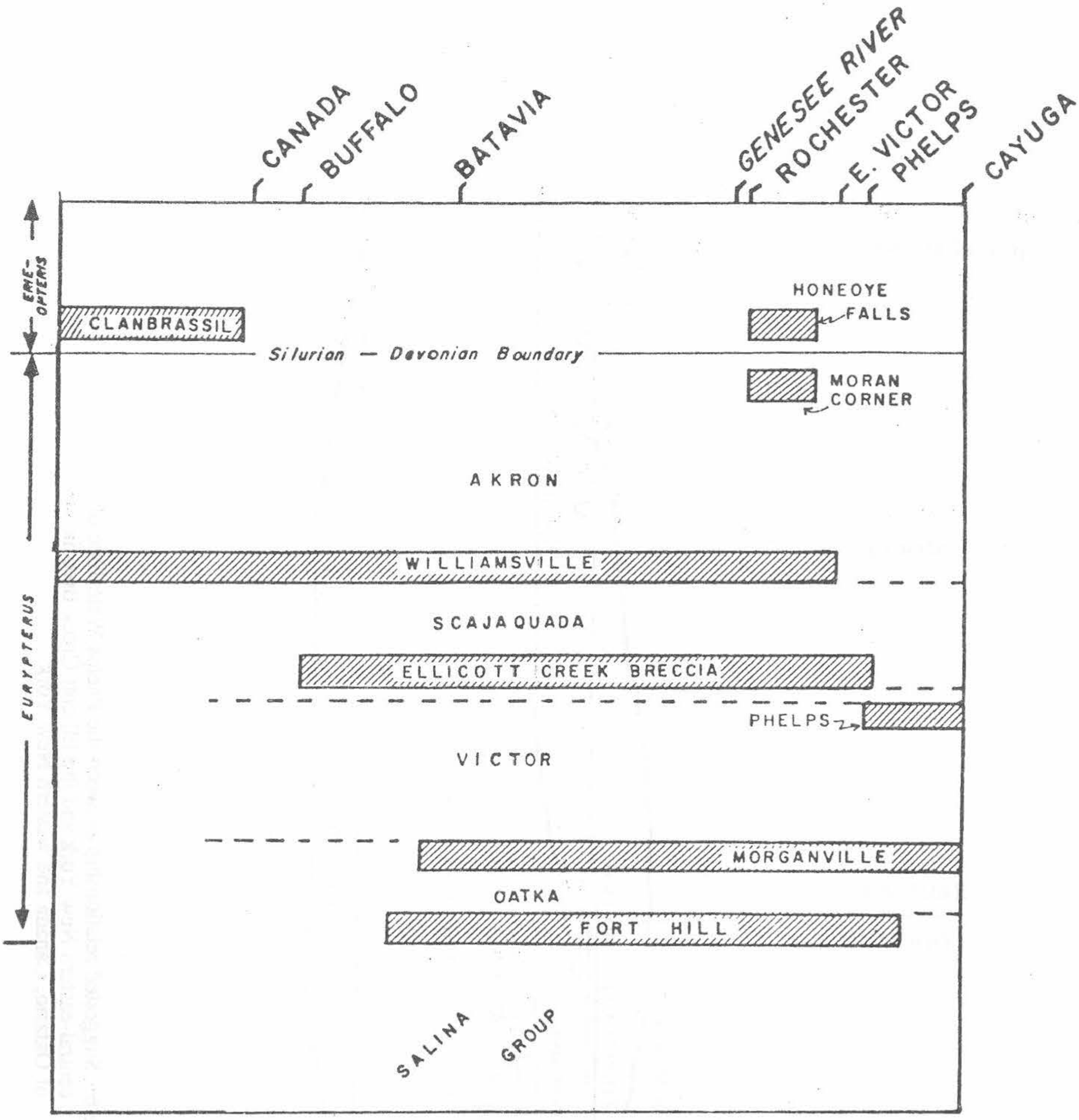

Figure 5. Distribution of the Late Silurian and Early Devonian Eurypterid-bearing Waterlimes (not to scale).

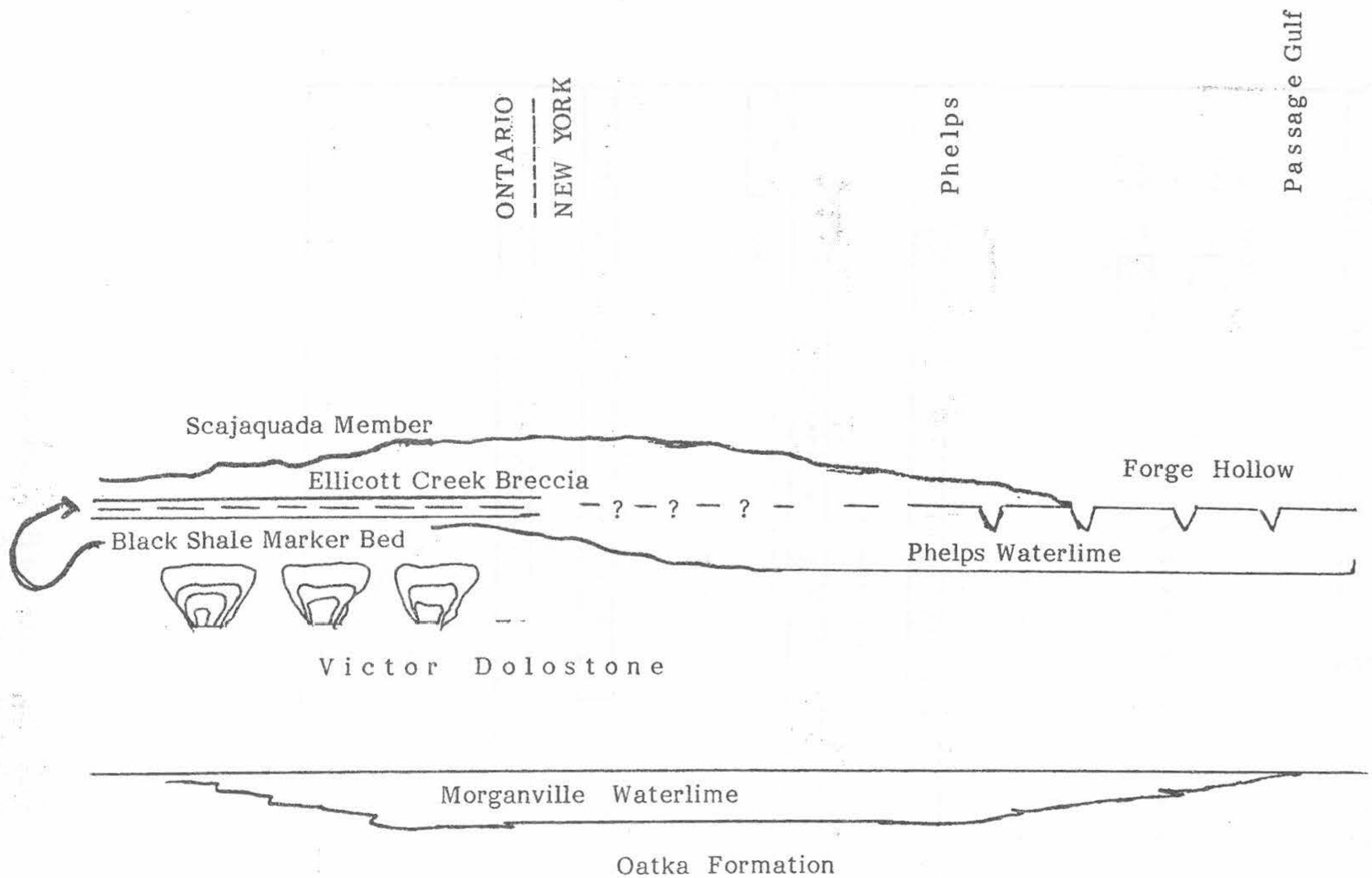

Figure 6. Suggested relationship between the Phelps Waterlime of central-eastern New York and the Ellicott Creek Breccia of Ontario, Canada and western New York.

Ontario, Canada Bertie Group	Western New York Bertie Group

Cobleskill Fm.
Williamsville Fm.
Scajaquada Fm.
Fiddlers Green Fm.
  Ellicott Creek Breccia
  Phelps Waterlime?
  black shale unit
  Victor Member
  Morganville Waterlime
Oatka Formation
	Moran Corner Waterlime
	Cobleskill Fm.
	Williamsville Fm.
	Scajaquada Fm.
	Fiddlers Green Fm.
	  Ellicott Creek Breccia
	  Phelps Waterlime
	  black shale unit
	  Victor Member
	    C limestone
	    B dolostone
	    A limestone
	  Morganville Waterlime
	Oatka Formation
	Fort Hill Waterlime

FIDDLERS GREEN FORMATION

Type section: Butternut Creek, north of Jamesville, New York.

In the type area the Fiddlers Green Formation is about 10 meters thick and consists of an upper eurypterid-bearing member that is believed to be continuous from the type Phelps Waterlime of western New York, east to the famous *Eurypterus* bed at Spohn Hill south of Herkimer.

The middle member is mostly dolomitic, but limestone beds are known. This portion of the Fiddlers Green Formation was termed the Victor Dolostone previously and contains a small fauna consisting of brachiopods, ostracods, stromatolites, and eurypterid remains. Throughout much of the region the lowermost Fiddlers Green Formation is a waterlime with fossils only rarely evident. This member is the Morganville Waterlime and is often straticulate and, at least at at some localities, contains salt hoppers and other evidence of hypersalinity.

On the Niagara Peninsula, a brecciated waterlime unit occurs just beneath the Scajaquada Formation. When traced into New York, the beds were found to correspond to a thicker (2.5m.) section at Ellicott Creek, Williamsville that was previously termed Ellicott Creek Breccia (see Figure 5). While the precise relationships across the area are not currently known, I have suggested that the Ellicott Creek Breccia is stratigraphically higher and younger than the Phelps Waterlime that occurs across much of the outcrop belt (east-west). A zone of mudcracks marks the top of the Phelps Waterlime throughout its extent. In Canada, a black shale occurs at the base of the Ellicott Creek Breccia and is used as a marker bed.

Black Shale Marker Bed

Peculiar platy dolomitic black shale, apparently unfossiliferous, occurs as a marker bed separating the Ellicott Creek Breccia from the main mass of the Fiddlers Green Formation below (Ciurca, 1982). I suggest this black shale be termed the Black Shale Marker Bed. This bed is prominent on the Niagara Peninsula and is useful for readily identifying the sequence of waterlimes and dolostones present. I believe the Black Shale Marker Bed is present at Ellicott Creek at Williamsville, New York where a re-entrant occurs at the base of the type Ellicott Creek Breccia and just above a brachiopod-rich waterlime of the Victor or Phelps Member of the Fiddlers Green Formation.

Maximum thickness of the black shale bed is about 15 centimeters. Thickness variation may have resulted from fluctuations in the development of the algal mounds below. Crude stromatolitic structures are also found in the middle of the overlying Ellicott Creek Breccia at several localities. Figure 6 illustrates the current concept of the relationship of western occurrences of the Ellicott Creek Breccia with that of the Phelps Waterlime to the east. For a more complete discussion of the Fiddlers Green Formation see Hopkins (1914, 1969), Rickard (1962, 1969), Ciurca (1973, 1978, 1982, 1986), Hamell (1981, 1985, 1986), qne Hamell and Ciurca (1986).

SCAJAQUADA FORMATION

Argillaceous dolostone constitutes most of the Scajaquada Formation in the Niagara Peninsula of Ontario and western New York. Most of the rock is thin-bedded and chert nodules are evident at several horizons. No fossils have ever been described from this unit except for rare eurypterid remains from a thin waterlime bed near the base in the Batavia area (NYS Thruway roadcut).

Eastward the Scajaquada Formation thickens. At Phelps (NY Rte 88 roadcut) the Onondaga Limestone and a basal sandy unit (Springvale?) overlie a very thin sequence of the Scajaquada Formation. At this locality, red stained salt-hoppers are abundant. Eastward, and presumably southward, the Scajaquada Formation is replaced by the gypsiferous Forge Hollow Formation (an arbitrary cutoff near Auburn, New York).

It is possible that part of the Scajaquada/Forge Hollow interval is correlative with the Ellicott Creek Breccia of western New York and the Niagara Peninsula of Ontario. Favorable localities for studying the Scajaquada Formation include Glen Park at Ellicott Creek, Williamsville; inactive quarry east of Clarence; Neid Road Quarry north of LeRoy; Mud Creek near Victor; and the NY 88 roadcut north of Phelps at the I-90 overpass.

WILLIAMSVILLE WATERLIME

Type Section: Ellicott Creek at Williamsville, N.Y.

The Williamsville Waterlime can readily be divided into four units at a number of localities in Ontario and western New York. The lower waterlime has been the primary supplier of specimens of *Eurypterus lacustris* and *Pterygotus cummingsi* in recent years, particularly from localities in the type area (Ridgemount Quarry) and the famous Bennett Quarry at Buffalo.

Above the lower waterlime unit (A) is a thin sequence (B) bearing brachiopods, the most important being *Eccentricosta jerseyensis* known principally from the Cobleskill Formation of central/eastern New York and from the Keyser Formation of Pennsylvania (see Ciurca, 1982, p. 113).

Williamsville C is almost a repetition of Williamsville A but little is known about the distribution of fossils within the unit. Williamsville D is a transitional unit. It is a waterlime with conchoidal fracture, large ostracods and eurypterid remains. It is slightly mottled, but not as intensely as the Cobleskill Formation above. A stylolitic contact has been observed between Williamsville D and the Cobleskill Formation at some localities. Williamsville D, in Ontario, is believed to be the source of most of the Canadian *Pseudoniscus* remains.

Some portions of the Williamsville Formation, particularly Williamsville A, are varvelike. Fresh rock, as seen mostly in the Ontario quarries, is resistant to collection of fossils. Conchoidal fractures occur in all directions. Upon weathering, however, bedding planes part and the fauna becomes evident. In Ontario, the most important species are *Eurypterus lacustris* and *Pterygotus cummingsi*. The fauna has been described previously (Ciurca, 1982), but I want to emphasize here that *Eurypterus lacustris* is a very distinctive eurypterid and is not known from any other horizon. Its occurrence thus far is limited to the region from Haggersville, Ontario eastward to Victor, New York. I have now observed this eurypterid at Manchester, New York, along Canandaigua Outlet, where it is exceedingly rare (2 specimens), being replaced by *Paracarcinosoma scorpionis* Fauna (Ciurca, 1973; Hamell and Ciurca, 1986).

COBLESKILL FORMATION

Throughout western New York and the Niagara Peninsula, the Williamsville Waterlime is overlain by massive mottled dolostone. This poorly fossiliferous sequence is about 20 feet thick and is usually referred to the Akron/Cobleskill (see Rickard, 1962 for more detail). No eurypterids are definitely known from the Cobleskill Formation of this region, but eastward facies changes occur and *Eurypterus*-bearing limestone and dolostone are encountered. A more detailed description of the Cobleskill Formation was presented earlier (Ciurca, 1982).

MORAN CORNER WATERLIME (New)

Type Section: Small creek south of Moran Corner about 10 miles south of Rochester, New York.

Reference Section: Honeoye Creek, downstream from NY 65, Honeoye Falls, New York.

An unnamed waterlime unit lying stratigraphically above the Cobleskill Formation, was recognized by Ciurca (1982, p. 101, p. 111). It is suggested that this waterlime be termed the Moran Corner Waterlime with important sections as listed above. The Moran Corner Waterlime is lithologically similar to the Phelps Waterlime of the Fiddlers Green Formation. It is about one meter thick and represents a regressive phase of the waterlime (carbonate) cycle with a mudcracked horizon at the top of this unit. Salt hoppers are present as well as an eurypterid fauna.

The Moran Corner Waterlime completes a cycle analogous to the cyclical pattern found in the Fiddlers Green Formation as illustrated below.

Moran Corner Waterlime	Phelps Waterlime
Cobleskill Formation	Victor Member
Williamsville Waterlime	Morganville Waterlime

It should be noted that subsequent waterlimes occur in Ontario, Canada and Western New York are part of the Helderbergian transgressive-cyclic sequences, contain *Erieopterus*, and are believed to be Lower Devonian in age (Gedinnian). A biostratigraphic discontinuity between the Moran Corner Waterlime and the Honeoye Falls Formation, ie. between the *Eurypterus* and *Erieopterus* Zones seems possible (Ciurca, 1967, 1982).

To the west, the Moran Corner Waterlime is unknown. In Canada the Helderbergian Clansbrassil Formation rests directly upon the residual beds of the Cobleskill Formation, apparently disconformably (Figure 5).

CLANBRASSIL FORMATION

Overlying the Cobleskill Formation in the region from Byng to Haggersville, Ontario is a sequence of very fine-grained dolostones, the Clanbrassil Formation (Ciurca, 1982). Type locality is the abandoned quarry at Clanbrassil, but wonderful exposures are available in a number of quarries at Byng, Cayuga, and Haggersville.

The Clanbrassil Formation is about 25 feet thick and is unconformably overlain by the Bois Blanc Limestone. Beneath this unit are the mottled Cobleskill (Akron) fine-grained dolostones (Figure 4).

The eurypterid, *Erieopterus*, is the sole fossil thus far obtained from the Clanbrassil Formation. It is a particularly common form and occurs primarily in the lower portion of the formation. The Clanbrassil Formation is correlative with part or all of the Manlius Group of central New York which is regarded as Gedinnian in age (See Figure 5).

SUMMARY

A variety of eurypterids are found throughout the Late Silurian-Early Devonian sequences of New York and Ontario, Canada. The importance of eurypterids for corhas been albeit neglected, I believe the more we know about their occurrences, the more we will find them useful in relating sequences that are geographically far apart.

Waeringopterus is turning out to be of widespread occurrence and I expect that, sooner or later, it will show up in the Silurian rocks of Pennsylvania. It forms a relatively narrow zone near the base of the Syracuse Formation.

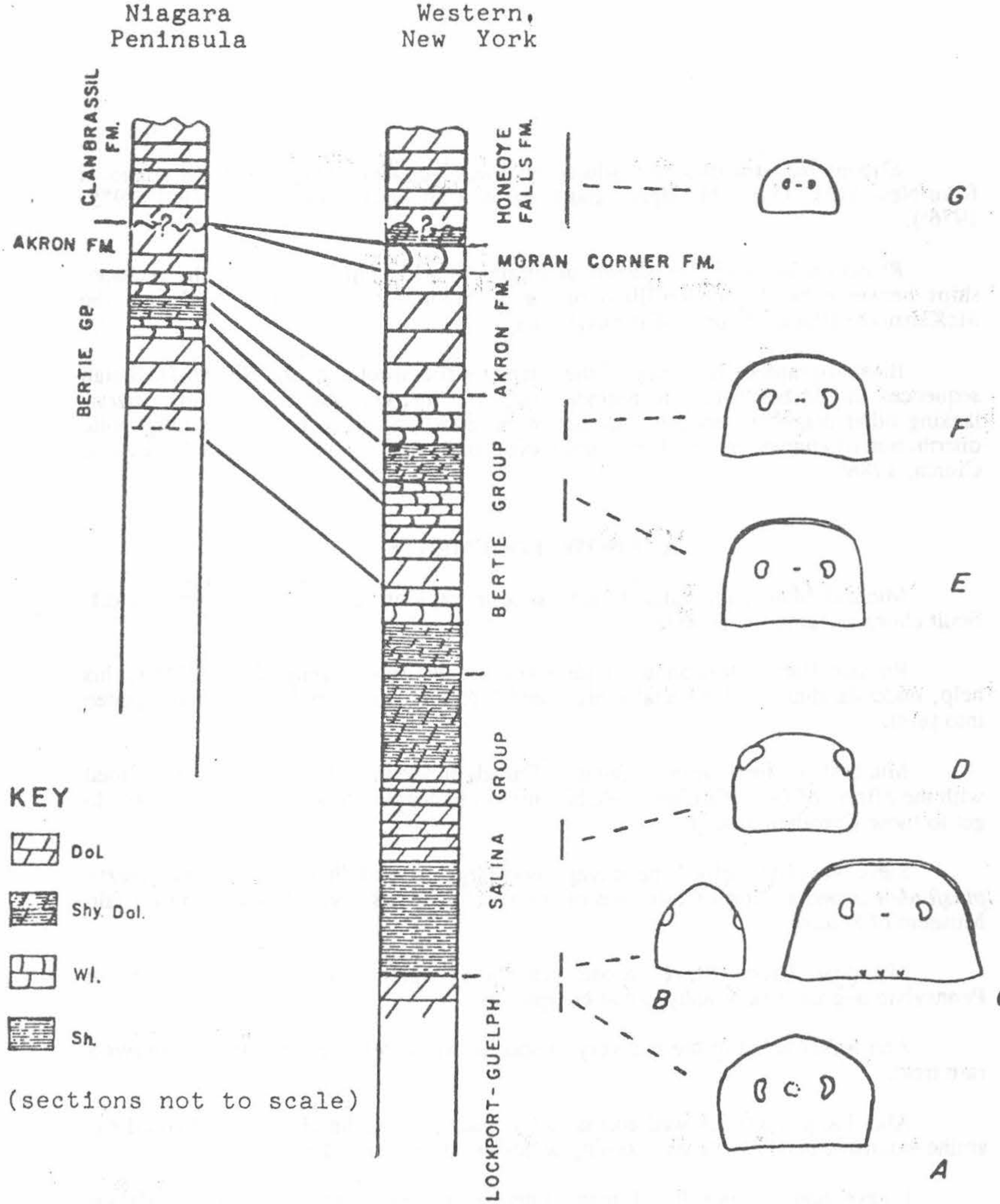

Figure 7 Eurypterid Biostratigraphy: Zonation based on the stratigraphic distribution of characteristic Silurian and Devonian eurypterids, A) Tylopterella, B,C) Hughmilleria socialis, Eurypterus pittsfordensis (respectively), D) Waeringopterus, E) Eurypterus remipes, F) Eurypterus lacustris, and G) Erieopterus.

Erieopterus straddles the Siluro-Devonian boundary and is currently known from New York, Ohio, Michigan, and Ontario, Canada (Ciurca and Gartland, 1975; 1976)).

Rhinocarcinosoma (not shown in Figure 6) will help to establish the relationships between the Sconondoa/Illion of the Lockport Group in New York and the McKenzie/Mifflintown strata of Pennsylvania.

Biostratigraphically, most of the characteristic species of the Silurio-Devonian sequences should be utilized in regional studies. Most eurypterids occur in horizons lacking other diagnostic species. An eurypterid zonation, based upon the stratigraphic distribution of characteristic Silurian and Devonian forms, is given in Figure 7 (see also Ciurca, 1986b).

ACKNOWLEDGEMENTS

Michael Muto gave valuable assistance in excavating the "*Para*" zone, a difficult chore working under water.

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Much of the field work in Ontario, Canada in the mid 1970's was accomplished with the efforts of Gene Gartland. We had many challenging times fighting blizzards to get to those Canadian quarries.

Steve Pavelsky helped me salvage two large stromatolites from the *Eurypterus pittsfordensis* bed at North Chili; one of the specimens has been placed in the Buffalo Museum of Science.

My dear friend Steve Jarose generously helped me do field studies in Pennsylvania-great stratigraphy, great eurypterids.

Ann Raker aided in the recovery of specimens of *Parascarcinosoma scorponis*-a rare treat.

Alan Lang freely allowed access to his quarry on Spohn Hill where I could examine extensive bedding planes exposing windrows of eurypterid material.

I have had the benefit of many interesting geoconversations with Professor Carlton Brett - I really appreciate it Carl.

This work is dedicated to the late Erik N. Kjellesvig-Waering from whom I had the benefit of ten years of fruitful exchange of information and ideas; to my dear friends, Suzi and Rich Hamell; and to those who try to preserve our wild spaces.

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ROAD LOG

Road log is divided into two parts. Part 2 only if time permits.

PART 1

Point-Point Mileage	Cummalative Mileage	Description
0.0	0.0	Inspection Station entering Canada.
0.1	0.1	EXIT Fort Erie. Follow sign to Rte 3.
0.5	0.6	TURN RIGHT onto Rte. 3 West.
0.2	0.8	Ideal Donuts on left.
0.3	1.1	McDonalds on right, proceed west.
2.6	3.7	Pink Elephant on right.
1.1	4.8	Stonemill Road.
0.2	5.0	TURN RIGHT onto Ridgemount Road.
0.7	5.7	Ridgemount Quarries Ltd. Aggregate Div. of Walker Industries. Quarry on left.
0.8	6.5	TURN LEFT onto Bridge Street.
0.2	6.7	Quarry overpass. Park on left.

STOP 1 Ridgemount (Campbell) Quarry

Camillus Shale or Oatka Shale forms the quarry floor. Above this is a thin representation of the Morganville Waterlime followed by massive beds of the Victor Dolostone. Several feet of Ellicott Creek Breccia are accessible on the northeast side of the quarry and from this many eurypterids have been obtained (Ciurca and Gartland, 1976). The higher strata, including the Williamsville Waterlime, are all visible in the quarry walls. The Devonian Bois Blanc Formation is particularly fossiliferous in this quarry.

0.2	6.9	Return to Ridgemount Road. TURN RIGHT, follow Ridgemount Road south.
1.5	8.4	Route 3 intersection. TURN RIGHT (west) toward Port Colburne.
2.0	10.4	Ridgeway Battlefield.
0.1	10.5	Intersection Ridge Road (signal light), continue west.
3.9	14.4	Entering Port Colbourne Township.
2.9	17.3	Gasline.
3.2	20.5	TURN RIGHT, Rte. 140 North.
0.6	21.1	Chippawa Road. Port Colbourne Quarries Ltd. entrance on right. Fine section of the Bertie Group and overlying strata in this quarry complex. CONTINUE north toward Welland.
4.0	25.1	Welland City Line. Population 46,000.
0.1	25.2	TURN RIGHT. Intersection Rte. 58A.
0.1	25.3	BEAR RIGHT
0.1	25.4	TURN RIGHT, Rte. 58A West.
0.5	25.9	Intersection Rusholme Road. CONTINUE west.

STOP 2 Welland Canal Underpass Roadcut

SYRACUSE FORMATION (SALINA GROUP). A portion of the Syracuse Fm. is well exposed exhibiting gypsum beds, fine-grained dolostone replete with cavities formed by dissolution of evaporites. Crude algal mounds are present and the facies developed here is identical to that displayed in the type area in central New York.

Waeringopterus, characteristic of the lower or transitional beds of the Syracuse Fm., occurs here in the argillaceous dolostones.

0.5	26.4	CONTINUE into tunnel.
0.3	26.7	Leaving tunnel.
1.6	28.3	TURN LEFT, intersection Rte. 58. Port Colbourne 8 km., CONTINUE SOUTH.
1.3	29.6	Entering City of Port Colbourne. Population 16,000.
2.0	31.6	Outcrop.
1.2	32.8	Jct. Rte. 3, McDonald's, TURN RIGHT (west).
1.2	34.0	Entering WainFleet Township.
0.8	34.8	Law Quarry on right. Fine sections exposing Bertie Group, Bois Blanc Limestone.
2.6	37.4	Ostryhon Corners.
3.0	40.4	Wainfleet
1.6	42.0	FOLLOW Rte. 3 west.
3.1	45.1	Winger
3.2	48.3	Town of Dunnville. Population 11,500.
7.1	55.4	Downtown Dunnville. CONTINUE west Rte. 3.
0.8	56.2	STOP SIGN. TURN LEFT. DO NOT GO RIGHT onto Main Street west. Grand River in sight.
1.4	57.6	SIGNAL LIGHT, Queen Street. TURN RIGHT.
0.1	57.7	Grand River.
0.2	57.9	Byng Island.
0.2	58.1	Grand Island BBQ. TURN LEFT, Rte. 11.
0.3	58.4	Dunnville Rock Products Ltd. Quarry and Plant. TH & B Bldg., 6620 Broad Street East. Trip Part 1 ends. Go back or begin Trip Part 2.

STOP 3 Quarry at Byng

The Bertie Group is prominent in the lower portions of the quarry. Particularly important is the sequence above the Cobllekill Formation at this site. The Clanbrassil Formation makes its appearance beneath the unconformity at the base of the Bois Blanc Formation. In this quarry the Clanbrassil Fm. consists primarily of waterlimes, i.e. very fine-grained dolostones having conchoidal fractures. The only fossil obtained from the Clanbrassil Fm. at this locality is *Erieopterus*.

TRIP PART 2 (if time permits)

0.0		Leave quarry.
0.2	0.2	TURN LEFT. Head back to RTE. 3
0.1	0.3	JCT., TURN RIGHT to Grand River.
0.4	0.7	Grand River.
0.1	0.8	JCT. Main Street. Dunnville. TURN LEFT. Proceed to Rte.3 (Grand River on left).
0.6	1.4	STOP SIGN, JCT. Rte. 3, proceed west on Rte 3.
5.0	6.4	Railroad Crossing.
0.2	6.6	Railroad Crossing.
1.7	8.3	Canborough, follow Rte. 3 west.
1.9	10.2	Town of Haldiman, Population 18,500.
1.8	12.0	Canfield
1.3	13.3	JCT. 56
0.3	13.6	Railroad Crossing.
3.8	17.4	Cayuga
0.6	18.0	JCT. Rte. 54.
0.2	18.2	Grand River.
1.2	19.4	JCT. Rte. 8.
1.2	20.6	Decewsville.
1.3	21.9	Cayuga Quarry (Crushed Stone).

STOP 4 Cayuga Quarry

This large quarry complex contains an important section including the Williamsville Waterlime and the Clanbrassil Formation. *Erieopterus* seems to be more common in the Clanbrassil Fm. and in the quarries at Haggersville.

0.6	22.5	Dry Lake Road. TURN RIGHT.
0.1	22.6	Railroad Crossing.
2.4	25.0	STOP SIGN, TURN RIGHT.
0.1	25.1	Clanbrassil.
0.7	25.8	Abandoned quarries on both sides of road. Stone Crest Farm.

STOP 5 Abandoned Quarry

Type section Clanbrassil Formation. The Clanbrassil Formation occurs in the walls of an abandoned quarry at the Stone Crest Farm.

END OF TRIP

TRIP II - SUNDAY

ROAD LOG

SCENIC ROUTE

Starting Point: Sign (N.Y. Power Authority, Administration Bldg., Switchyard, Warehouse) on NY 265 heading south from I-190 near Lewiston, New York.

STOP 1

Section high in Lockport Group ("Oak Orchard" of Zenger). Large stromatolite mounds.

START LOG

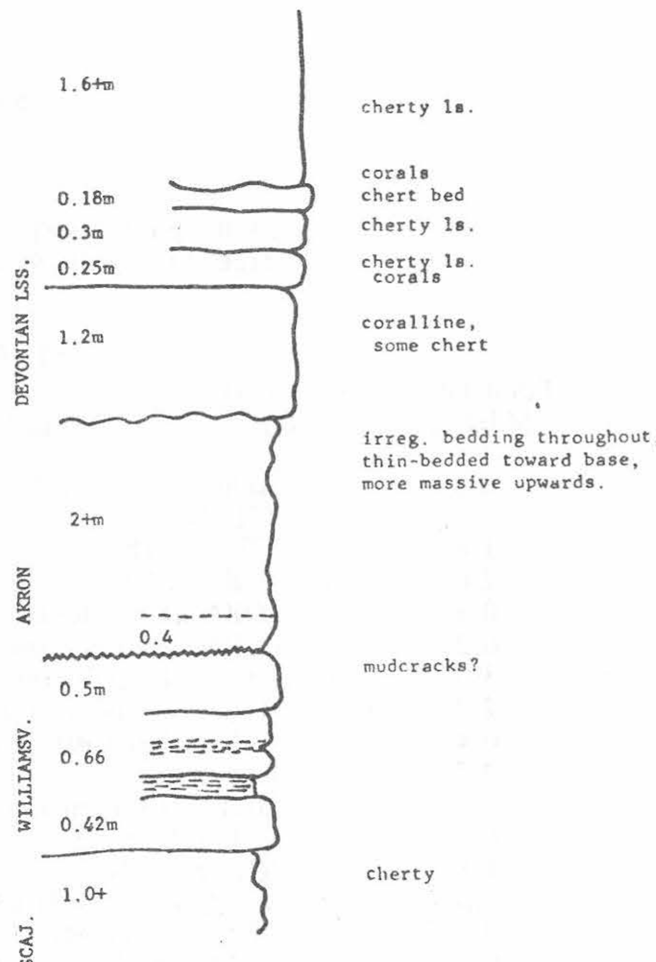
Point-Point Mileage	Cummalative Mileage	Description
0.0	0.0	Follow NY 265 (Military Rd.) south to NY 324 (Sheridan Drive).
0.7	0.7	JCT. NY 31.
1.8	2.5	JCT. NY 182.
2.0	4.5	TURN RIGHT, follow NY 265.
0.4	4.9	TURN LEFT, follow NY 265.
0.2	5.1	TURN LEFT, follow NY 265.
3.0	8.1	City of North Tonowanda. Niagara River on right.
2.0	10.1	JCT. 429, continue south on NY 265.
0.4	10.5	JCT. NY 384 BEAR LEFT. Follow NY 384.
0.7	11.2	Erie County.
		JCT 324 (Sheridan Dr.) TURN LEFT, follow NY 324 east.
6.5	17.7	JCT. NY 263.
1.8	19.5	JCT. NY 277.
1.0	20.5	Mill Street. TURN RIGHT.
0.9	21.4	Glen Ave. TURN RIGHT.
0.1	21.5	GLEN PARK-manmade wonder complete with ducks.

STOP 2 ELLICOTT CREEK BRECCIA

Type Sections: Ellicott Creek Breccia, Williamsville Waterlime.

Figure below shows stratigraphic section of part of Bertie Group.

0.0	21.5	Head back to Mill Street.
0.1	21.6	Mill Street. TURN RIGHT to JCT. NY 5 (Main Street). TURN LEFT (east). FOLLOW NY 5.
2.5	24.1	JCT. NY 78.
2.5	26.6	JCT. NY 324.
2.6	29.2	Clarence, New York.
1.1	30.3	Antique World on right.
1.9	32.2	View from escarpment on left-WHEW!
0.5	32.7	Clarence Materials Corp. Redi Mix Div. Main St. Plant.



Section at Williamsville, New York, Ellico Creek, west side, tributary showing Scajaqu through Akron Formational relationships.

STOP 3 FIDDLERS GREEN FM. ETC

Inactive quarry exposing a portion of Fiddlers Green Fm. up through Cobleskill Fm. Large quarry in Onondaga Limestone just to the east.

1.6	34.3	JCT. to NY 93, continue east.
3.0	37.3	Pembroke, New York. JCT. NY 77 TURN LEFT. Proceed to Indian Falls.

STOP 4 INDIAN FALLS-FALCON CREST

4.4	41.7	Falls consists of massive Victor Dolostone-lush green algal mats still thrive on bedding planes, in pools and channels. No eurypterids have been seen.
0.1	41.8	TURN RIGHT, head back to NY 5 via NY 77.
2.3	44.1	JCT. NY 5 TURN LEFT, heading to Batavia and points beyond.
11.4	55.5	Downtown Batavia-nice place.
1.1	56.6	Leaving Batavia.
2.2	58.8	Neat boulder on left, continue east on NY 5.
1.5	60.3	Genesee LeRoy Stone Quarry on RIght.
0.6	60.9	Stafford, N.Y.
3.8	64.7	LeRoy, N.Y.
0.7	65.4	JCT. NY 19 TURN LEFT (north).
2.0	67.4	Railroad overpass. BE PREPARED TO PULL OFF ROAD.
0.7	68.1	JCT Oatka Trail - TURN RIGHT, PULL OVER.

STOP 5

Stratigraphic section showing Camillus Shale (Salina Group) and overlying Fort Hill Waterlime.

0.0	68.1	FOLLOW Oatka Trail (east).
0.3	68.4	TURN RIGHT - Oatka Trail (WINDING ROAD).
0.8	69.2	JCT Circular Hill Rd. TURN RIGHT, proceed up the escarpment.
1.7	70.9	JCT. Gulf Road. TURN LEFT.

STOP 6

0.8	71.7	Dolomite Products Co., Inc. LeRoy Plant. Old locomotive ensemble, quarries in Onondaga.
0.0	71.7	Continue east on Gulf Road.
0.5	72.2	Neid Road. TURN LEFT.

STOP 7

0.2	72.4	Erratics of Victor Dolostone - note *Whitfieldella* brachiopods littering bedding planes. Continue north on Neid Rd.
0.1	72.5	JCT. Town of LeRoy Refuse Area. TURN LEFT.

STOP 8

0.1	72.6	Neid Road Quarry (Ciurca, 1973). Bertie Group and overlying Onondaga Limestone exposed here.
0.1	72.7	JCT. Neid Road. TURN RIGHT.
0.3	73.0	STOP - JCT. Gulf Road. TURN LEFT (east).
1.0	74.0	County of Monroe - Flint Hill Road.
1.2	75.2	Genesee Country Museum, Nature Center on Right.
1.3	76.5	JCT. NY 36. TURN LEFT.
0.2	76.7	Oatka Creek.
0.1	76.8	JCT. 383. TURN RIGHT. Follow NY 383 north - ENJOY BEAUTIFUL SCENERY.
3.7	80.5	Garbutt, N.Y.
0.2	80.7	JCT. Union St. TURN RIGHT.
0.1	80.8	Railroad Crossing. Ronzo's Grocery on right.

STOP 9

TURN RIGHT into Oatka Park. Exposures of Syracuse Fm. (Salina Group) along Oatka Creek. Ruins of buildings-old gypsum mines.

0.1	80.9	FOLLOW Union Street back to NY 383.
0.1	81.0	STOP-TURN RIGHT onto NY 383 north.
0.8	81.8	Railroad overpass.
0.6	82.4	Scottsville, N.Y.
1.5	83.9	JCT. NY 253. Follow NY 383 north (Rochester-6.0 mi.).
8.6	92.5	JCT. I-390.

END OF TRIP