Sedimentary Structures and Paleoenvironmental Analysis of the Bertie Formation (Upper Silurian, Cayugan Series) of Central New York State

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INTRODUCTION

The Bertie Formation (Upper Silurian, Cayugan Series) of New York State, is world renowned for its spectacular eurypterid fossils. However, details of the total fauna (not just the eurypterids) and its significance, along with an understanding of the depositional environment, lags behind most other rock units in New York State. An understanding of the depositional environment of the Bertie is further complicated by a lack of published studies on the sedimentary structures that occur in the formation. Almost without exception, the fossils and the sedimentary structures have been treated as separate and totally unrelated aspects. Only minor attention had been paid to the structures (e.g., mud-cracks, and the windrow accumulations).

The writers are fully aware that the fossils are an important aspect in the overall interpretation of the depositional environment of the Bertie, especially when they are considered as primary sedimentary structures. Matters of identification and errors of stratigraphic relations of the fossils in the Bertie strata severely limit their usefulness and delay understanding of their significance (see further comments under Paleontology).

With regard to the sedimentary structures, we know of no published studies that list, describe, and discuss all of them. Buchwald (1963) did study some of them. The main purpose of this paper, then, is analyses of all of the known sedimentary structures of the Bertie, with emphasis on their use in the interpretation of the depositional environment.

Although only three stops will be made in the field, all are key outcrops. Stop 1 is at Forge Hollow, New York, where a complete sequence of the Bertie with both lower and upper contacts with the Camillus and Cobleskill Formations, respectively, are exposed. Stop 2 is at Jerusalem Hill, where the upper Fiddlers Green and the lower Scajaquada Members are exposed. Stop 3 is at Passage Gulf, where the lower contact with the Camillus is exposed.

ACKNOWLEDGMENTS

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HISTORY

The Bertie Formation was named by Chapman (1864, p. 190-191) for approximately 50 feet of "...thin-bedded grayish dolomites, interstratified towards the base with a few brownish shales, and with a brecciated bed composed chiefly of dolomitic fragments" that were exposed near the Township of Bertie, Ontario, Canada. The name was first used in New York State by Schuchert (1903, p. 171-172) in his study of the Manlius Formation. Subdivision of the Bertie in its historical perspective is shown in Table 1. A more complete historical perspective is found in Rickard (1953; 1962). The terminology used in this paper follows that of Rickard (1975); Correlation with the terminology of Ciurca (1973) is included in the discussions.

Stratigraphically, the Bertie is the uppermost formation of the Salina Group (Cayugan Series). The New York State Geological Survey (1970) has mapped the Bertie either as undifferentiated from the Salina Group (eastern map sheets), or with the Camillus and Cobleskill Formations (western map sheets). The only continuous cross-section of the Bertie for New York State is found in Rickard's Masters thesis (1953).

Historically, the Bertie Formation has received sporadic attention, mainly because of its prolific and spectacular eurypterid fauna. One of the main purposed of many older studies had been to reconcile the habitat of the eurypterids with the occurrence of other fossils, and the presence and/or absence of some of the sedimentary structures (e.g., mudcracks) into a coherent environmental interpretation.

According to Alling (1928, p. 42, 54), O'Connell (1916) interpreted the Bertie as a deposit of clastic origins. She interpreted the Bertie as having been either 1) a flood-plain deposit; 2) a deltaic deposit; or 3) a playa-lake deposit. Her conclusions on the habitat of the eurypterids were that they lived in rivers, because few other fossil groups were rarely, if ever, found in the same beds as the eurypterids. Also, most of the eurypterids found were disarticulated exoskeletons.

Ruedemann (1916c; 1925) disputed O'Connell's work. He concluded eurypterids were truly marine organisms, in that the entire fauna was of truly marine origins. The disarticulated nature of the eurypterids was, according to Ruedemann (1916c, p. 114) a natural phenemnon for chelicerate arthropods in a near-shore setting. Ruedemann's (1925, p. 12-13) conclusions as to the environment of the Bertie, were that it was a lagoon deposit, formed behind (north of) coral reefs (located further south). According to Leutze (1959, p. 99) this interpretation by Ruedemann (that the Bertie formed behind coral reefs) was based upon a misinterpretation of the stratigraphy in the Syracuse, N.Y. area. With the exception of the depositional strike, Ruedemann's views are currently the most widely accepted (Alling and Briggs, 1961; Rickard, 1962; Treesch, 1972).

A small number of workers are currently re-examining the Bertie. Ciurca (1973, 1978, 1982) has contributed much toward an understanding of the stratigraphy with regard to the eurypterids. An up-dated review of the stratigraphy and sedimentology of the entire Salina Group was done by Treesch (1972).

TABLE 1. Historical review of the terminology of the Bertie Formation.

Vanuxem (1842)	Hall (1843)	Chapman (1864)	Schuchert (1903)	Hartnagel (1903)	Hopkins (1914)
Fourth *or* Magnesian, and Third *or* Gypseous Deposits of the Onondaga Salt Group	Fourth *or* Magnesian *or* Waterlime *or* Hydraulic Deposit of the Onondaga Salt Group	Bertie Formation	Bertie Formation	Eurypterus-bearing Salina beds	Bertie Formation
					Camillus Shale
					Fiddlers Green Member, of the Camillus Shale

Chadwick (1917)	Rickard (1962) Western N.Y.	Rickard (1962) Central N.Y.	Rickard (1975)	Ciurca (1978) Rochester, N.Y.
Buffalo Member, Bertie Formation	Williamsville Member, Bertie Formation	Oxbow Member, Bertie Formation	Williamsville Member, Bertie Formation	Williamsville Formation, Bertie Group
Scajaquada Member, Bertie Formation	Scajaquada Member, Bertie Formation	Forge Hollow Member, Bertie Formation	Scajaquada Member, Bertie Formation	Scajaquada Formation, Bertie Group
Falkirk Member, Bertie Formation	Falkirk Member, Bertie Formation	Fiddlers Green Member, Bertie Formation	Fiddlers Green Member, Bertie Formation	Phelps Mbr. Victor Mbr. Morganville Mbr. all of Fiddlers Green Fm., Bertie Group
Oatka Member, Bertie Formation	Oatka (?) Member, Bertie Formation	Not recognized		
				Oatka Formation

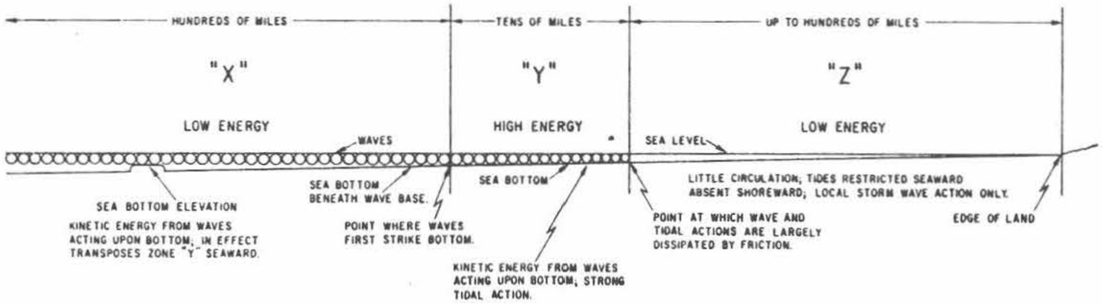

Figure 1. Generalized section showing the energy zones in epeiric seas. Not to scale. From: Irwin (1965, fig. 3, p. 450).

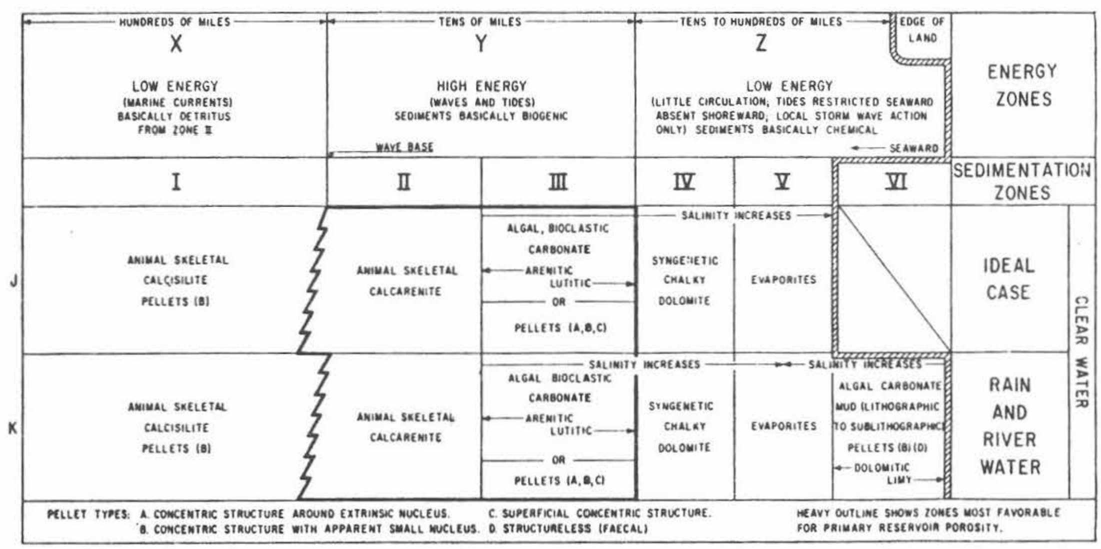

Figure 2. Energy and sedimentation zones of epeiric seas. From: Irwin (1965, fig. 5, p. 452).

Recently, attempts have been made to apply the epeiric sea model of Irwin (1965) (Figs. 1 and 2) to the Bertie (Belak, 1980; Hamell, 1981; Tollerton, 1983). Additional field work is necessary before this model is fully applicable to the Bertie. In this respect, the present paper adds to what is currently known about the depositional environment of the Bertie. Much remains to be learned. Problems that remain are: 1)Has the Bertie been subjected to compaction? If so, how much, and what kind of compaction mechanism produced the features observed? 2)How were the shrinkage cracks formed? Several different types of shrinkage cracks are reported in the literature, but precise descriptions for their recognition are lacking. This problem pertains not only to the Bertie, but also to other sedimentary deposits that contain shrinkage cracks (e.g., the Green River Formation, a lake deposit. See Smoot, 1983, for a discussion on shrinkage cracks). 3)Are the reported isolated occurrences of fossils and sedimentary structures real or apparent? Have we been too enamored with the eurypterids to the point of indifference? Have we misidentified many fossils; given them new names based on size and stratigraphic position (e.g., comments by Leutze, 1959); or collected the fossils from the wrong stratigraphic unit (e.g., Syracuse Fm. and Cobleskill Fm.) referring them to the Bertie based on lithologic similarity? 4)How saline was the environment? Can the water chemistry be determined or inferred? 5)How deep was the water? 6)Do the fossils really represent a life assemblage throughout, or only for certain beds? 7)Was dolomitization primary or secondary? Has dolomitization obscured the details of the depositional environment - structures as well as the fauna? Some of the possibilities, along with preliminary results of study and suggestions for further study, are presented throughout this paper.

The results of our work in assigning Irwin's (1965) epeiric sea model to the Bertie are summarized in Table 6. In the tabulation, the previously proposed models and the epeiric sea model are compared with respect to the expected occurrences of the fossil groups, sedimentary structures, and the interpretations furnished from their study.

PALEONTOLOGY

With the exception of the eurypterids, the fossils found in the Bertie Formation are generally poorly preserved, and in need of extensive study. A preliminary, provisional, revised faunal list is given in Table 2. An extensive discussion of the revision is beyond the scope of the present paper, as are comparisions with the lists in Ruedemann (1925) and Monahan (1931). However, a few remarks are warranted with regard to their paleoecological implications.

Several writers (Clarke and Ruedemann, 1912; Ruedemann, 1925; Alling, 1928; Leutze, 1959, 1964; Alling and Briggs, 1961; Treesch, 1972; Ciurca, 1973, 1978, 1982) have remarked that most of the fossils reported as occurring in the Bertie are restricted to single outcrops, with only a small number of species occurring at more than one outcrop. The question then, is why would the organisms be so different and so restricted throughout the Bertie? This restriction may be apparent, and due in part to three factors. First, the past practices of naming species based upon differences in size and stratigraphic position (comments by Leutze, 1959,

TABLE 2. Provisionally revised faunal list of the Bertie Formation. Sources given in parentheses.

Coelentrates
- Conularids (Ruedemann, 1925; Monahan, 1931)
  - *Metaconularia perglabra* (Ruedemann)
- Corals (Ruedemann, 1925)
  - **Aulocystis* sp.
  - *Stromatopora* sp.

Bryozoans (Ruedemann, 1925; Monahan, 1931)
- *Hederella* cf. *canadensis* (Nicholson)
- *H.* sp.
- **Stigmatella* sp.

Brachiopods (Ruedemann, 1916a, 1925; Monahan, 1931; Leutze, 1959; Berdan, 1972; Ciurca, 1982)
- *Eccentricosta jerseyensis* (Weller)
- *Howellella eriensis* (Grabau)
- *Lingula semina* Ruedemann
- *L. subtrigona* Ruedemann
- *Morinorhynchus ? interstriatus* (Hall)
- *Orbiculoidea* cf. *numulus* Hall and Clarke
- *Protathryris sulcata* (Vanuxem)

Mollusca
- Gastropods (Ruedemann, 1916a, 1925; Leutze, 1959)
  - **Loxonema bertiensis* Ruedemann
  - **Murchisonia (Hormotoma) gregaria* Ruedemann
  - *Platyceras (Platyostoma)* sp.
- Cephalopods (Ruedemann, 1916a, 1925; Monahan, 1931; Flower, 1948; Leutze, 1959)
  - *Dawsonoceras oconnellae* Ruedemann
  - *Mitroceras gebhardi* (Hall)
  - *"*Orthoceras*" *vicinus* Ruedemann
  - *Pristeroceras timidum* Ruedemann
- Pelecypods (Ruedemann, 1925; Monahan, 1931; Leutze, 1959)
  - *Goniophora* (?) sp.
  - *Hercynella buffaloensis* O'Connell
  - *Nuculites salinensis* (Ruedemann)

Worms (Ruedemann, 1925)
- *Ruedemannella obesa* (Ruedemann)
- *Spirorbis* sp.

Arthropods
- Scorpions (Ruedemann, 1925; Kjellesvig-Waering, 1966)
  - *Archaeophonus eurypteroides* Kjellesvig-Waering
  - *Proscorpius osborni* (Whitfield)
- Eurypterids (Clarke and Ruedemann, 1912; Ruedemann, 1925; Kjellesvig-Waering, 1958, 1963, 1964; Ciurca, 1982)
  - +*Acanthoeurypterus dekayi* (Hall)
  - +*A. wellsi* Kjellesvig-Waering
  - +*Alloeurypterus linsleyi* Kjellesvig-Waering
  - *Buffalopterus pustulosus* (Hall)
  - *Clarkeipterus testudineus* (Clarke and Ruedemann)
  - *Dolichopterus herkimerensis* Caster and Kjellesvig-Waering
  - *D. Jewetti* Caster and Kjellesvig-Waering
  - *D. macrocheirus* Hall
  - *D. siluriceps* Clarke and Ruedemann

TABLE 2. (Continued)

Arthropods
- Eurypterids (Continued)
  - *Erettopterus (Erettopterus) grandis* (pohlman)
  - *Eurypterus remipes lacustris* Harlan
  - *E. remipes remipes* DeKay
  - *Paracarcinosoma scorpionis* (Grote and Pitt)
  - *Pterygotus (Acutiramus) macrophthalmus cummingsi* (Grote and Pitt)
  - *P. (A.) macrophthalmus macrophthalmus* (Hall)
  - *P. (Pterygotus) cobbi* Hall
  - *P. (P.) juvenis* Clarke and Ruedemann
- Phyllocarids (Ruedemann, 1925)
  - *Ceratiocaris acuminata* Hall
  - *C. aculeata* Hall
  - *C. maccoyana* Hall
  - *C. minuta* (Ruedemann)
- Xiphosurans (Ruedemann, 1925; Ciurca, 1982)
  - *Bunaia woodwardia* Clarke
  - *Limuloides (?) eriensis* (clarke)
  - *Pseudoniscus clarkei* (Ruedemann)
- Ostracods (Ruedemann, 1925; Monahan, 1931)
  - *Eukloedenella umbilicata* Ulrich and Bassler
  - *E.* sp.
  - *Leperditia alta* (Conrad)
  - *L. scalaris* (Jones)
  - *Zygobeyrichia* cf. *regina* Ulrich and Bassler

Echinodermata
- Edrioasteroids (Ruedemann)
  - *Pyrgocystis batheri* Ruedemann
- Machaeridians (Ruedemann, 1925)
  - *Lepidocoleus reinhardi* Ruedemann

Graptolites (Ruedemann, 1925)
  - *Climacograptus ultimus* Ruedemann
  - *Inocaulis lesquereuxi* (Grote and Pitt)
  - *Medusaegraptus gramminiformis* (Pohlman)
  - *Orthograptus (?)* sp.
  - *Palaeodictyota buffaloensis* Ruedemann

Conodonts (Barnett, 1972)
  - *Hindeodella* sp.
  - *Ligonodina* sp.
  - *Lonchodina greilingi* Walliser
  - *L. walliseri* Ziegler
  - *Neoprioniodus bicurvatus* (Branson and Mehl)
  - *Ozarkodina denckmanni* Ziegler
  - *O. media* Walliser
  - *Plectospathodus alternatus* Walliser
  - *Spathognathodus remscheidensis* Ziegler
  - *Trichonodella excavata* (Branson and Mehl)

Algae (Ruedemann, 1925)
  - *Callithmnopsis silurica* Ruedemann
  - *Morania (?) bertiensis* Ruedemann
  - *Sphenophycus (?)* sp.
  - LLH Stromatolites

TABLE 2 (Continued)

Vascular (?) Plants (Ruedemann, 1925; Banks, 1972, 1973)
Cooksonia hemispherica Lang
C. pertoni Lang
Hostimella silurica Goldring
Trace Fossils (Ruedemann, 1925)
Algal wrinkles
Chrondrites
Worm (?) trails (?)
Worm (?) excrementa (?)

* Genus and/or species possibly misidentified. Previous terminology provisionally accepted until original collections can be studied.

\+ Original descriptions not published (?). To date, these names only appear in Ciurca (1982).

p. 92-99, 114, 116-126, 142), in which case several species would then be synonymous. Second, mis-identification of the Bertie at various localities (see Leutze, 1959), in which case, several species reported as occurring in the Bertie would no longer be included in the faunal lists. Third, the poor state of preservation of the fossils, which upon further examination, may be found to be mis-identified, in which case several species would be synonymous.

The question of geographic restriction, however, may not be totally the result of man. Some of the reported isolated and/or patchy occurrences may be related to the harsh and variable hypersaline environment with extremely low-angle slopes. Such occurrences as the graptolite *Medusaegraptus* and the plant *Cooksonia*, both occuring at Passage Gulf, would then be related to such natural factors as storms, persistent yet local tide pools, or transgressive/regressive sea levels. An attempt to develop this idea further would be the tabulation of species and numbers of individuals with geographic and stratigraphic position. Such a study is currently being planned. Although the work is greatly hampered by the lack of adequately preserved fossils and by the abundance of mid-identified (?) fossils, preliminary results indicate that the geographic and stratigraphic restrictions are not as extensive as previously supposed.

Published discussions on the paleoecology of the Bertie fauna have been essentially restricted to the eurypterids, although minor comments have been made in the older papers under remarks in the descriptions of new fossils (e.g., Ruedemann, 1916a, 1916b, 1925; Monahan, 1931). Generalizations have been made on the paleoecology of the entire fauna of the Salina Group (Alling, 1928; Leutze, 1959, 1964; Treesch, 1972), but detailed discussions relative to the Bertie fossils are lacking.

The following comments on the Bertie fossils are only generalizations, in that they have been studied from the aspect of being primary sedimentary structures. Specific details of the fauna are not only beyond the scope of the present paper, but merit more careful attention to detail than we have been able to give them so far. For example, are the eurypterids the only fossils that tend to show a preferred orientation (Ciurca, 1978) ? What is the extent of abrasion and disarticulation of the fossils? Do some of the fossils indicate ecological competition with its resulting restrictions?

The conularids would seem to indicate shallow, marine conditions for the Bertie (Tasch, 1973, p. 140). Too few specimens are known to speculate on anything else.

Poorly described corals reported by Ruedemann (1925) may have been mis-identified and they may be bryozoans. Until the original collections are re-studied, their true categorization and paleoecological significance is unknown.

The presence of the bryozoans would seem to indicate warm, shallow, marine conditions, as the forms reported are small and delicate branching types. The material collected by the senior writer has not been studied in detail at this writing.

Brachiopods of the Bertie would seem to represent the *Lingula* and possibly the *Eocoelia* Communities of Ziegler (1965). However, the complications of identification and stratigraphic misplacement severely limit this idea.

The gastropods, both high- and low-spired forms, indicate a marine environment (Knight, et al, 1960, p. I171). They appear to be more common in the lower parts of the Fiddlers Green and Williamsville Members. A few very small slabs collected from Passage Gulf show a preferred orientation for both forms. Whether this is a relect of the small specimen size, or an actual preferred orientation, is not known at present.

Cephalopods are orthocone and brevicone types. Although their geographic distribution is unknown at present, we believe that they indicate marine conditions for the Fiddlers Green and the Williamsville Members. That they have been washed in is considered unlikely as the material seen thus far does not show signs of either preferred orientation or of abrasion.

Pelecypods are less abundant than the brachiopods, and may have competed with them in the shallow marine environment. However, there are no indications, as yet, that they co-existed during the frequent oscillations of environmental conditions. To date, no specimens have been found by the writers with both pelecypods and brachiopods preserved together in undoubted Bertie strata.

The scorpions from the Bertie may or may not have been washed into the environment. Published information on the morphological characteristics of these animals are inconclusive as to whether thay were marine, brackish-water, or terrestrial invertebrates (Kjellesvig-Waering, 1961, p. 360). However, the total assemblage of fossils occurring with the scorpions and the eurypterids, strongly suggests a quiet, shallow, marine environment.

The Xiphosurans of the Bertie, *Limuloides*, *Bunaia*, and *Pseudoniscus*, are believed to have been benthonic, brackish-water organisms (Størmer, 1955, p. P16). A more detailed paleoecological account is not feasible at present because too few specimens are known, and their relationships to other organisms were not indicated when they were described.

The phyllocarids represent shallow marine, quiet-water conditions (Rolfe, 1969, p. R308). Further comments cannot be made until their relationships to other aspects of the Bertie are known.

The eurypterids fall into the Eurypteridae Phase (Kjellesvig-Waering, 1961, p. 793) of ecological environments, indicating an intermediate zone between normal marine and nonmarine environments. Additional study is necessary to determine if all eurypterid zones in the Bertie display a preferred orientation, or if they represent windrow accumulations, as suggested by Ciurca (1978). We agree with Ruedemann's views (1916c, p. 114) on the disarticulated nature of the eurypterids as being normal for chelicerate arthropods in a shallow, near-shore environment.

The ostracods, especially *Leperditia*, represents shallow, marine, tidal-flat environments (Berdan, 1968). The Leperditids are ubiquitous throughout the Fiddlers Green and the Williamsville Members. Some are found on the exoskeletons of some of the eurypterids, suggesting that they may have been scavengers.

The edrioasteroid, *Pyrgocystis batheri* Ruedemann, is cited by Regnell (1966, p. U157-U158) as having been tolerant of various substrate lithologies, living in soft muds or oozes, and indicating generally quiet, shallow, marine conditions.

Graptolites collected at Passage Gulf are only the carbonaceous thecae of *Medusaegraptus gramminiformis* Ruedemann, not the entire organism. These have either been washed in or disarticulated in situ by currents.

The conodonts indicate a shallow, marine environment (Müller, 1962, p. W87). Their stratigraphic distribution given in Barnett (1972, p. 903) shows that portions of the Fiddlers Green and Williamsville Members were shallow marine. However, only one locality was sampled. Additional collections are required before further comments can be made relative to the environmental conditions of conodonts (Barnett, 1971) for the entire geographic extent of the Bertie, as some of the conodonts may have been washed in.

With the exception of the stromatolites, the algae are poorly preserved. Thin, non-descript films occur on the bedding planes, and do not allow for accurate interpretations other than that they were probably marine. The stromatolites are discussed in more detail under sedimentary strucutres.

The plants *Cooksonia hemispherica* Lang and *C. pertoni* Lang have been found in the Bertie at Passage Gulf, and possibly in the Buffalo, New York area (Banks (Cornell University), 1983, oral communication). It is not known with certainty if they were washed in, or if they were native to the environment. In addition, the vascular nature of both species of *Cooksonia* and of *Hostimella silurica* Goldring has not been proven for the Bertie material (Banks, 1972, p. 367, 373). The idea that vascular plants may occur in the Bertie, however, is not new (Banks, 1972, p. 374). Regardless, their significance lies in the constraints placed upon any hypothesis of depositional environment for the Bertie.

The remainder of the Bertie fossils are too poorly known to comment on relative to their paleoecology. The same can be said with regard to the trace fossils, although a study of them is in progress. For example, infrequent coarser-grained-filled, relatively horizontal burrows are suggestive of either a burrowing crustacean (?) or of the worm *Ruedemannella obesa* (Ruedemann).

SEDIMENTARY STRUCTURES

Studies of sedimentary structures within the Bertie Formation, without exception, qualitatively use the structures to identify the depositional environment. One of the main purposes of this paper is to relate all of the sedimentary structures to a depositional environment, its subsequent history, and to discuss the significance of each structure in terms of epeiric sea sedimentation. Also, structural relationships as well as stratigraphic occurrences will be examined, and

TABLE 3. Sedimentary structures and bedding types occurring in the Bertie Formation. Forms marked with an asterick are those that have been observed at the field stops for this trip. Sedimentary structures and bedding types listed in approximate order of frequency.

Sedimentary Structures	Bedding Types
Shrinkage Cracks*	Tidal Bedding*
Gypsum Crystal Molds*	Massive Bedding*
Reticulate Ridge Halite Casts*	LLH Stromatolites*
Salt Hopper Casts	Nodular Bedding*
Mottled Coloration*	Cross-bedding
Micro-faults*	Intraformational Breccia
Mud Volcanos*	
"Diastemic Surfaces"*	
Trace Fossils*	
Windrows*	
Channels*	
Ripple Marks*	
Impact Prints*	
Oolites	

TABLE 4. Sedimentary structures and bedding types. Preliminary summary relative to placement within Irwin's (1965) energy and sedimentation zones. Structures marked with an asterick are not environmentally determinable at present.

Sedimentary Structures and Bedding Types	Epeiric Sea Model						
	X	Y		Z			
	1,	2	3	4	5	6	Land
Shrinkage Cracks						x	x
Gypsum Crystal Molds					x		
Reticulate Ridge Halite					x	x	
Salt Hoppers					x		
*Mottled Coloration							
*Micro-faults							
Mud Volcanos						x	
"Diastemic Surfaces"						x	x
Trace Fossils				x	x	x	
Windrow Accumulations				x	x		
Channels			x	x			
Ripple Marks					x	x	
Impact Prints						x	x
Oolites			x	x			
Tidal Bedding			x	x	x		
Massive Bedding	x	x	x				
LLH Stromatolites					x		
Nodular Bedding						x	x
Cross-bedding		x	x	x			
Intraformational Breccia	x	x	x				

where necessary or appropriate, to the fossils.

Table 3 lists all the currently known sedimentary structures occurring within the Bertie. Tabulation of the geographic and stratigraphic distribution of the structures and bedding types is not possible at this time, being the writers have not visited all known sites of the Bertie. Such a tabulation would greatly enhance the inferences regarding the depositional environment. Nevertheless, all the known sedimentary structures can be placed, without too much controversy, in the different energy and sedimentation zones of Irwin (1965) (Table 4).

A previous study by Tollerton (1983) outlined a general stratigraphic sequence of both the sedimentary structures and the fossils. The present paper presents more detailed work on the sequences. The sequences may be incomplete due to the effects of the depositional consequences of epeiric sea sedimentation (low-angle of depositional slope; compaction; frequent subaerial exposure; and reflux dolomitization).

Although the Bertie contains many sedimentary structures, most are either ignored, or not recognized as sedimentary structures. This condition exists for two reasons. First, most investigators are overly preoccupied with the eurypterids, to the exclusion of everything else. Second, the degree of preservation and the degree of weathering tend to obscure most of the structures. Many of them cannot be seen until the specimen has been cut and polished.

Structures that have been widely interpreted as mud-cracks (shrinkage cracks of desiccation origin) are common in the Bertie (Fig. 8). However, there is little direct evidence for their being interpreted as mud-cracks. Few of the diagnostic features (Table 5) that would substantiate the condition of subaerial exposure and subsequent desiccation are found directly associated with the Bertie shrinkage cracks. The only known sedimentary structures found associated with the shrinkage cracks are: 1)reticulate ridge halite casts; 2)small-scale mud volcanos; 3)micro-faults; and 4)LLH Stromatolites. With the possible exception of the reticulate ridge halite casts, the other structures are not exclusively indicative of subaerial exposure (Reineck and Singh, 1975). Preliminary studies show an apparent stratigraphic restriction of association. Thus far, the approximately top one foot of the upper-most beds of the Fiddlers Green Member are directly associated with the reticulate ridge halite casts, and the small-scale mud volcanos. Below this is another layer of shrinkage cracks associated only with the micro-faults. Another foot down is a third layer of shrinkage cracks associated only with the LLH Stromatolotes. Studies on the geographic continuity of this sequence are in progress.

Designation of a desiccation origin to shrinkage cracks is frequently based solely on their external appearance. Several blocks and slabs of the shrinkage cracks collected from the three layers mentioned above were cut and polished. The internal pattern found from all the shrinkage cracks (Fig. 3) was not expected for mud cracks solely of desiccation origin. Clearly, these shrinkage cracks are not simply due to subaerial exposure and desiccation. Their origins must account for both the internal pattern resembling a form of fluid escape and the surface polygonal pattern.

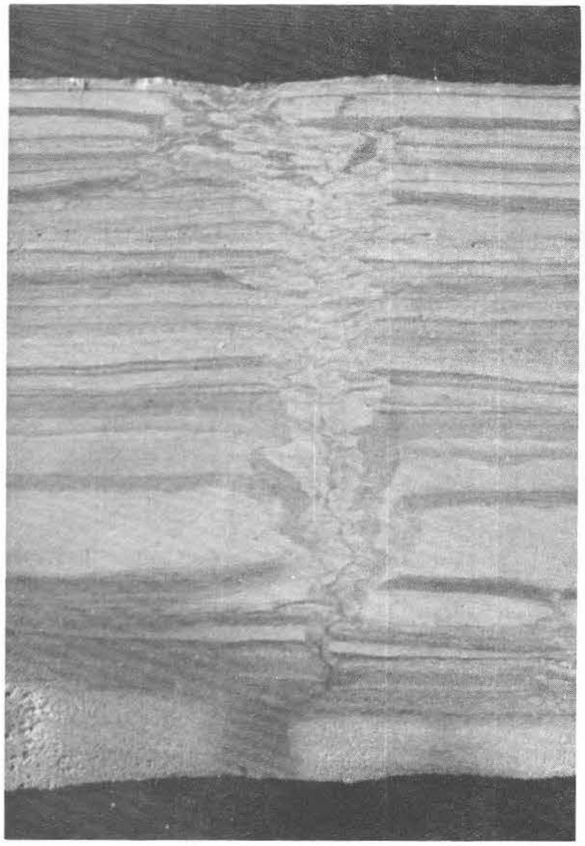

Figure 3. Desiccation crack in cross-section. Top of specimen is at top of photo. Approximately natural size.

Table 5. Summary of shrinkage cracks, origins, and characteristics. From: Plummer and Gostin (1981, Table 1, p. 1153).

Type of Shrinkage Crack and Plan Shape			Cross-Sectional Shape	Derivation of Infill	Number of Generations of Cracks	Preferred Orientation	Associated Features (Diagnostic)	Frequency Encountered in Geologic Record	Origin and Depositional Environment
DESICCATION	Polygonal	rectangular	V or U shaped	from above	can be multiple	?	raindrop imprints hailstone imprints bubble tracks foam impressions gypsum and/or salt casts flat-topped ripples vertebrate tracks etc.	uncommon	Algal or mud shrinkage by atmospheric drying. Exposed.
		hexagonal				none		rare	
		irregular						common	
	non-Polygonal	'incomplete'						uncommon	
		radial				?		rare	
		ribbon				parallel to water retreat			
SYNAERESIS		polygonal		from above or below	generally one	none	none	rare	Surface or substratal dewatering of submerged muds. Submerged.
		spindle				can be aligned	often with load phenomena	common	
		sinuous				along ripple troughs	ripple marks		

Oomkens (1966), in a study of the environmental significance of sand dikes, showed material from the Ubari Basin in Southwestern Libya (a playa setting), and from the Lower Permian of West Germany, as examples of sand dikes with polygonal surface patterns. His illustrations are remarkably similar to the Bertie material. His explaination of this structure applies to that observed in the Bertie, and increases our confidence in the environmental interpretation. Although Oomken's material is from a Recent playa setting, the basic processes are presumably the same, and are considered viable for epeiric sea environments. The sequence of events following Oomken's (1966, p. 146) interpretation is: 1)subaerial exposure; 2)shrinkage due to desiccation; 3)cracking; and 4)expulsion of the wet sediments from below the hard, impermeable surface layers. Evidence for such an interpretation for the Bertie is as follows: 1)generally V-shaped cross-section of the cracks; 2)"mobilized" internal pattern of the cracks; 3)the surface polygonal pattern; and 4)association of mud volcanos and mocro-faults with the cracks.

Additional support for this generic interpretation is found in the similarity of depositional regimes between coastal playa and sabkha settings, as well as lacustrine settings (Kinsman, 1969; Picard and High, 1972; Reineck and Singh, 1975; Shearman, 1978; Shinn, 1983b, and Smoot, 1983) with the depositional processes postulated for epeiric sea environments (Irwin, 1965).

For the present, a reconstruction of the paleosalinity based upon the shrinkage cracks (Baria, 1977) has not yet been attempted because of the many variables. However, as suggested by Shinn (1983b, p. 175), mudcracks preserved in carbonate rocks are almost invariably restricted to supratidal and upper intertidal zones.

The sedimentary structures shown in fig. 4 are interpreted as gypsum crystal molds. This interpretation is based on a comparision of similar material from Ohio, described by Summerson (1966). According to Summerson (1966, p. 223) the occurrence of gypsum crystal molds, in association with stromatolites and a restricted fauna, indicates conditions of a penesaline environment. Similar gypsum crystal patterns are observed in sabkhas and tidal flats of the Persian Gulf area (Kinsman, 1969; Reineck and Singh, 1975; and Shearman, 1979).

The sedimentary structures from the Bertie shown in fig. 5 have been interpreted by Tollerton (1983) as reticulate ridge halite casts. This form of skeletal halite was first described by Southgate (1982, p. 395) from silicified specimens from the Middle Cambrian of northern Australia, as "...a network of mutually perpendicular ridges that forms by the preferential precipitation of halite on the edges of cubes." According to Southgate (1982, p. 405), the reticulate ridge halite is indicative of very shallow brine pools that evaporated to dryness. Also the brines exhibited rapid variations in brine concentration. If the structures from the Bertie are indeed reticulate ridge halite, then they are strong evidence that at least portions of the Bertie were aubaerially exposed and desiccated, especially because of the associated desiccation cracks (as opposed to layers without desiccation cracks as reported in the Jurassic of Massachusetts by Parnell (1983, p. 711)). Exactly how shallow the brine pools were is still speculative. However, the experimental data of Southgate (1982, p. 404) suggests that reticulate

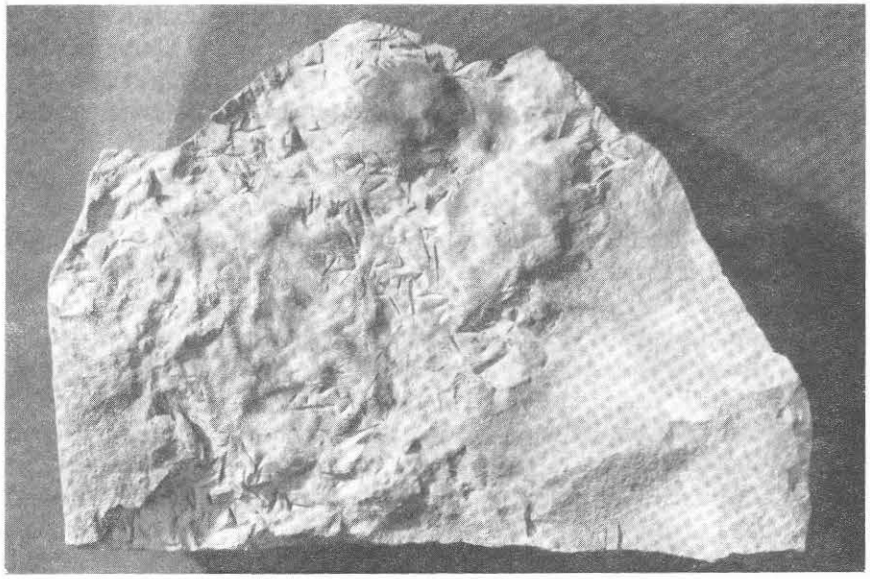

Figure 4. Gypsum crystal molds. Specimen collected from talus. Approximately one-half natural size.

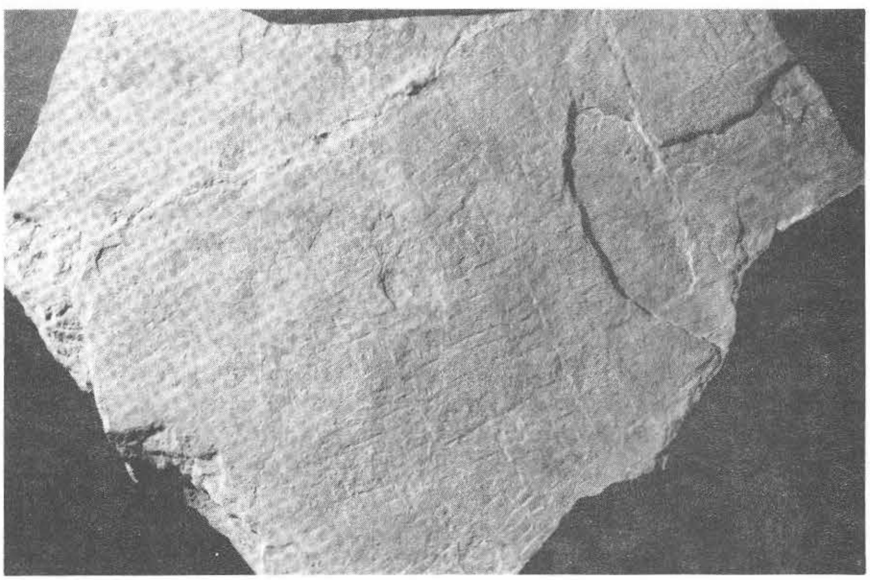

Figure 5. Reticulate ridge halite casts. Under-surface shown. Top shown in fig. 8. Approximately one-third natural size.

ridge halite, such as from the Bertie, may have precipitated in brine pools with depths on the order of only a few centimeters.

Although none have been observed by the writers, one example of salt hopper casts is reported by Ciurca (1978, p. 230) as occurring in the Fiddlers Green Member (his Phelps Member) at Passage Gulf. Ciurca also reports (1978, p. 230) that salt hoppers are characteristic of the upp ermost Fiddlers Green Member (his Phelps Member) at localities further to the west. This supports the extremely shallow-water origins postulated for the reticulate ridge halite casts. Experimental evidence from Southgate (1982, p. 404) suggests that with deeper water, the salt hoppers will form, while in shallow water, the reticulate ridge halite will form. The question remains, however, how shallow is shallow and how deep is deep. Published studies relating the distribution of skeletal halite morphologies with water depth seem to be inconclusive, at least quantitatively. Qualitatively, detailed field investigation of the size and abundance per square meter of the skeletal halite morphologoes may prove rewarding.

Some specimens from the Bertie that show a mottled coloration have been tentatively interpreted either as the result of bioturbation (fig. 6) or the result of compaction (fig. 7). Those specimens labelled as bioturbation (fig. 6) indicate an active infauna, even in extremely adverse ecological conditions (e.g., hypersalinity), as indicated by the association of salt (?) crystal molds. That the fauna was indigenous is indicated by the presence of geopetal brachiopod molds. Both of these are shown in fig. 6.

Those specimens identified as resulting from compaction (fig. 7) are virtually indistinguishable from the published figures of Shinn and Robbin (1983, fig. 15B, p. 607), and Shinn (1983a, fig. 1B, p. 621), both of which show the results of laboratory produced compaction on Recent shallow-water and lagoonal carbonate sediments. Beds showing the effects of compaction are apparently restricted to the lower portions of the Fiddlers Green Member. What process and mechanism produced the compaction? If the compacted beds are restricted to the lower portions of the Fiddlers Green Member, why don't the overlying beds also show effects of compaction?

The answers may lie in the nature of the stratigraphic record for the Bertie; a discontinuous nature that has not been recognized before. If the depositional record is discontinuous as suggested by the effects of compaction, then the Bertie Formation may have been deposited over a much longer period of time than previously supposed. On the other hand, the mottled beds may be burrowed subtidal beds, as the specimens closely resemble the published figures of Shinn(1983b, fig. 30, p. 190). Petrographic studies are in progress in an attempt to resolve the proper origin for these mottled beds.

The micro-faults seem to occur only with the shrinkage cracks, as well as with other structures found with the shrinkage cracks. The sense of movement is always that of a normal fault, and occur either en echelon or as micro-grabens. These structures are distinctly different from the off-set and "dropped" polygons of the larger shrinkage cracks. Whether these micro-faults are the result of compaction (Pettijohn and Potter,

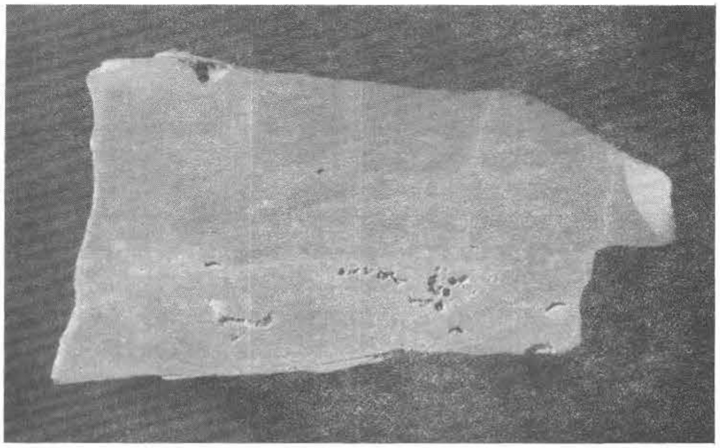

Figure 6. Mottled coloration due to bioturbation? Top of specimen at top of photo. Fenestrate (birdseye) structure or salt molds near bottom. Geopetal brachiopod in lower right. Approximately natural size.

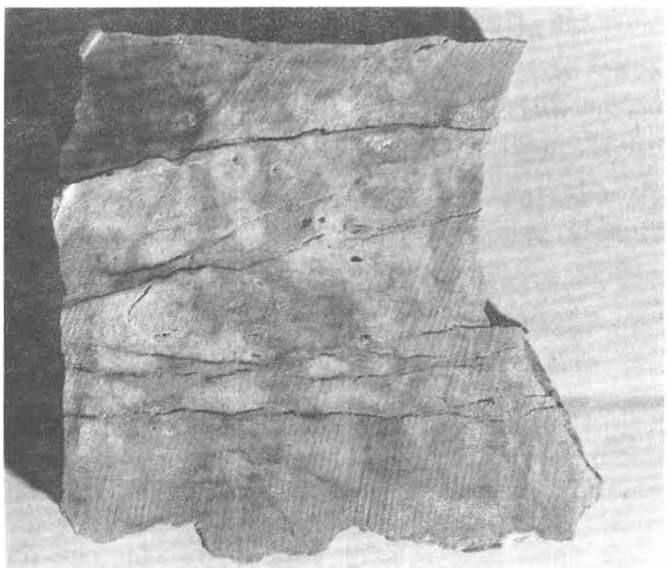

Figure 7. Mottled coloration due to compaction(?) or normal subtidal deposition (?). Top of specimen at top of photo. Approximately one-half natural size.

1964, Plate 111B), flowage (Wells, Prior, and Coleman, 1980), or earthquake shock (Sims, 1973), is not known. Any of these hypotheses are equally valid. One suggestion for study would be detailed outcrop maps of their in situ occurrences and orientations.

Only one specimen of mud volcanos exists in the senior writer's collection (figs. 8 and 9). As such, the specimen has neither been slabbed, nor have thin-sections been made. However, other sedimentary structures are in direct association with the specimen; shrinkage cracks, and reticulate ridge halite casts. This assemblage of sedimentary structures suggests that the mud volcano is the result of water expulsion due to either desiccation or compaction, or both.

So far as is known, the mud volcanos are only found in the uppermost zone of shrinkage cracks within the Fiddlers Green Member, about three inches below the contact with the overlying Scajaquada Member.

The term "diastemic surface" is used to designate bedding-plane surfaces that, when associated with features indicating subaerial exposure, also indicate extremely short periods of non-deposition. The actual duration of non-deposition is not yet determinable.

Because the depositional regime of epeiric sea sedimentation operates on an extremely shallow slope, such "diastemic surfaces" are believed to be a logical consequence of such a depositional regime. These "diastemic surfaces" are common throughout the Bertie, with at least nine such surfaces identified in the Fiddlers Green Member at Passage Gulf. It may be that these "diastemic surfaces" are PAC boundaries, but this is open to discussion, and requires additional field study.

Only a few trace fossils are known from the Bertie; those tentatively identified as the result of bioturbation (see mottled coloration), and those found with the ripple marks discussed later. Another form of trace fossil are the stromatolites. Forms of stromatolites that are not recognized as such are discussed later. They strongly resemble the intensely shriveled algal mats figured by Ginsburg (1957, fig. 15, p. 95). Some algal structures may have been erroneously identified as "worm burrows".

Several writers (e.g., Ciurca, 1978; and Hamell, 1981) have noted the occurrence of oriented fossils in parallel zones that are about one to two feet in width. These parallel zones may be either windrow accumulations, or due to the effects of compaction (most of the microfaults occur in the immediately overlying beds). Excavation for the eurypterids will generally expose the windrows. However, specimens of complete windrows are not known to exist, a condition which greatly hampers detailed study of their origins. Windrow accumulations in the Bertie are concentrations of generally undeformed and unbroken fossils, and may indicate deposition in quiet, shallow-water areas of tidal flats (Reineck and Singh, 1975). Such accumulations as have been seen in the field, suggest a biocenose, because 1)gross size-measurements of whole eurypterids follow a normal distribution, and 2)high-spired gastropods, ostracods, and brevicone cephalopods have been found on the same bedding planes as the eurypterids.

Figure 8. Small-scale mud volcano with shrinkage cracks. View is top of bed. Bottom shown in fig. 5. Approximately one-third natural size.

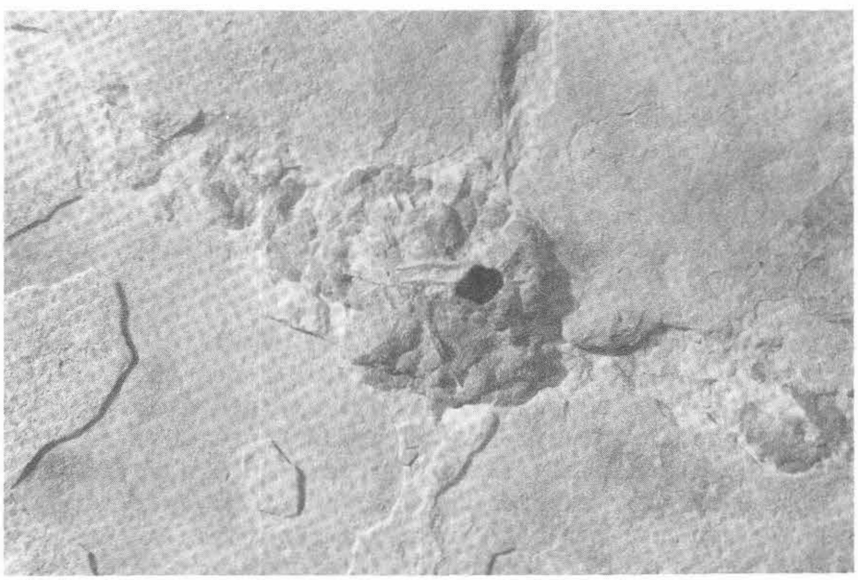

Figure 9. Close-up of fig. 8; small-scale mud volcano. Current flow toward the left. Current modified fecal mound? Approximately twice natural size.

A few examples of probable small-scale channels are known from the Bertie. However, the specimens are from small loose pieces, which severely limits interpretation. They may be cross-beds or cross-laminations, or may be due to the effects of compaction. Until specimens are located in situ, their value for interpretation is limited.

Only one specimen of ripple marks is known to the writers. It was collected at stop 2, on Jerusalem Hill Road. The material is a fine-grained, gray, dolomicrite, with a ripple index of 9. The ripples are slightly asymmetric, and probably formed by wind generated small waves. Depth of water was probably extremely shallow.

Features similar to worm burrows and worm trails with these ripple marks, supports a shallow-water interpretation, in that none of the burrows and trails show any signs of either rapid escape or burial.

No specimens of raindrop imprints from the Bertie have been reported in the literature: they may yet be found. Tracing the known horizons from the Brayman Formation containing such raindrop imprints may not prove fruitful, as such horizons are probably very local.

Using the technique of Metz (1982), structures shown in fig. 10 have been positively identified as hailstone imprints. To date only one horizon of hailstone imprints has been located in the Bertie.

Strata containing oolites have been observed only at outcrops of the Bertie in Canada. Although exposures in western New York State have not been examined by the writers, oolites have not been reported from any Bertie outcrop in New York State. It may be that the oolitic beds seen in the Canadian outcrops were deposited in "deeper" water and subjected to subtidal and tidal current action, yet still within the overall realm of shallow epeiric sea sedimentation (sedimentation zone III in energy zone Y; see figs. 1 and 2). Another explaination, is that dolomitization by reflux action has obscured the oolites in the "shallower" New York State sections.

Included in tidal bedding are flaser, lenticular, wavy, and laminated bedding. Although no detailed work has been completed at this writing, preliminary study of slabbed specimens suggests that they are of tidal origin.

Massive bedding appears to be volumetrically dominant, and devoid of sedimentary structures. Additional detailed petrographic studies are in progress at this writing.

Those structures from the Bertie shown in figs. 11 and 12 are interpreted as LLH Stromatolites of Logan, Rezak, and Ginsburg (1964). Portions of tidal bedding (e.g., laminated bedding) may also be stromatolitic in origin; additional thin-section study is needed before further comments can be made.

The significance of the LLH Stromatolites in the Bertie is that they indicate very shallow water that was subject to low wave and/or current action (Logan, Rezak, and Ginsburg, 1964, p. 77-79).

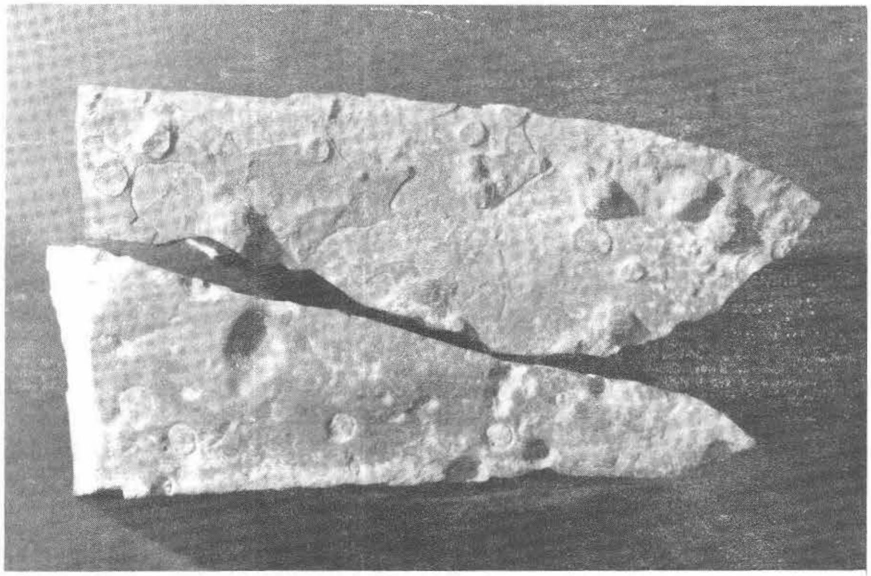

Figure 10. Hailstone imprints. Cast on top specimen is bed bottom. Approximately three-quarters natural size.

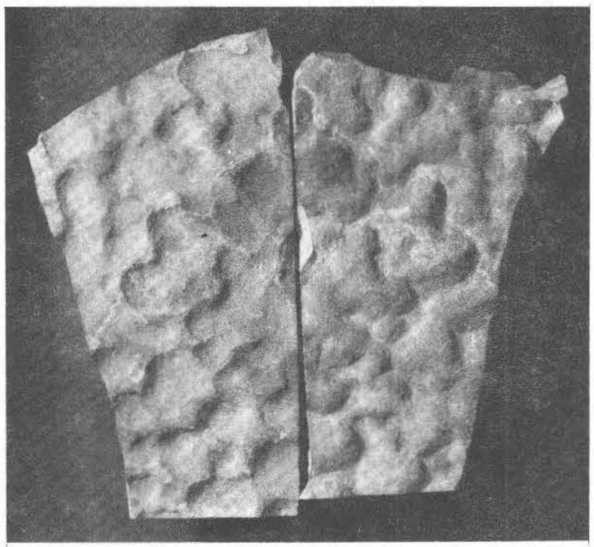

Figure 11. LLH Stromatolites. Cast on right is top of bed; mold on left is bottom of bed. Approximately one-quarter natural size.

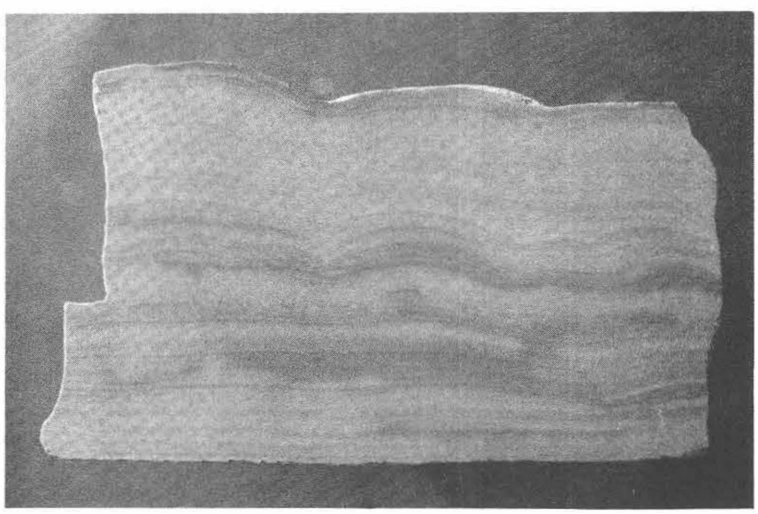

Figure 12. Corss-section of LLH Stromatolites. Top of specimen is top of photo. Approximately natural size.

Nodular bedding is observed in the Scajaquada Member wherever the member is exposed. The nodules appear to be calcite pseudomorphs after gypsum, and are indicators of supratidal deposition (Kinsman, 1969, and Shearman, 1978).

Cross-bedding has been reported from the Bertie (Ciurca, 1978), but none has been observed by the writers in the field. It is believed that the cross-bedding that may occur would be of small scale and of local stratigraphic importance because of the extremely low slopes involved in epeiric sea sedimentation.

An intraformational breccia in the Bertie probably represents a storm deposit. Only one such bed has been identified, which is the Ellicott Creek Member of Ciurca (1982, p. 103). Its absence east of Phelps, New York, may be evidence of regressive conditions within the Bertie. Whether the breccia indicates 1)that wave and/or current action was insufficient to form the breccia in the "shallower" eastern portions of the epeiric sea, or 2)that the probability of preservation was greater in Irwin's energy zones Y and X, are not clear.

CONCLUSIONS

When the total assemblage of fossils and sedimentary structures are examined and studied in detail, the epeiric sea model of Irwin (1965) is preferred over previously proposed environmental models. The epeiric sea model is the only model that apparently accounts for all the fossil groups, sedimentary structures, and interpretations proposed in the present paper (Table 6).

Although several problems still remain, it is hoped that this paper will stimulate further research, not only on the Bertie Formation, but also with regard to the formation of many of the sedimentary structures whose origins are unknown or are highly problematic. Such research is presently being conducted by the writers.

TABLE 6. Environmental relationships of the Bertie Fm. for proposed models

Structures/Bedding Types	River	Delta	Playa Lake	Lagoon	Epeiric Sea
Shrinkage Cracks			x	x	x
Gypsum Crystal Molds			x		x
Reticulate Ridge Halite Casts			x		x
Salt Hopper Casts			x		x
Mottled Coloration	x	x	x	x	x
Micro-faults	x	x	x	x	x
Mud Volcanos			x		x
"Diastemic Surfaces"		x	x		x
Trace Fossils		x		x	x
Windrow Accumulations		x		x	x
Channels	x	x		x	x
Ripple Marks	x	x		x	x
Impact Prints		x	x	x	x
Oolites				x	x
Tidal Bedding		x		x	x
Massive Bedding			x	x	x
LLH Stromatolites				x	x
Nodular Bedding			x	x	x
Cross-bedding	x	x		x	x
Intraformational Breccia		x		x	x
Fossils					
Conularids				x	x
Corals				x	x
Bryozoans		x		x	x
Brachiopods		x		x	x
Gastropods	x	x		x	x
Cephalopods		x		x	x
Pelecypods	x	x		x	x
Worms				x	x
Scorpions		x		x	x
Eurypterids	x	x		x	x
Phyllocarids		x		x	x
Xiphosurans				x	x
Ostracods		x		x	x
Edrioasteroids				x	x
Graptolites				x	x
Conodonts		x		x	x
Algae				x	x
Vascular (?) Plants	x	x		x	x
Trace Fossils		x		x	x
Interpretations/Observations					
Extremely shallow water	x	x	x	x	x
Extremely low-angle slope		x	x		x
Frequent periods of exposure			x	x	x
Reflux dolomitization			x	x	x
Geographic restriction of fossils	x	?			x
Geographic restriction of structures	x	?	x		x
Stratigraphic restriction of fossils	x	?			x
Stratigraphic restriction of structures	x	?	x		x
Hypersaline conditions			x		x
Little or no wave action	x		x		x
Little or no current action			x	x	x
Biocenoses		x		x	x

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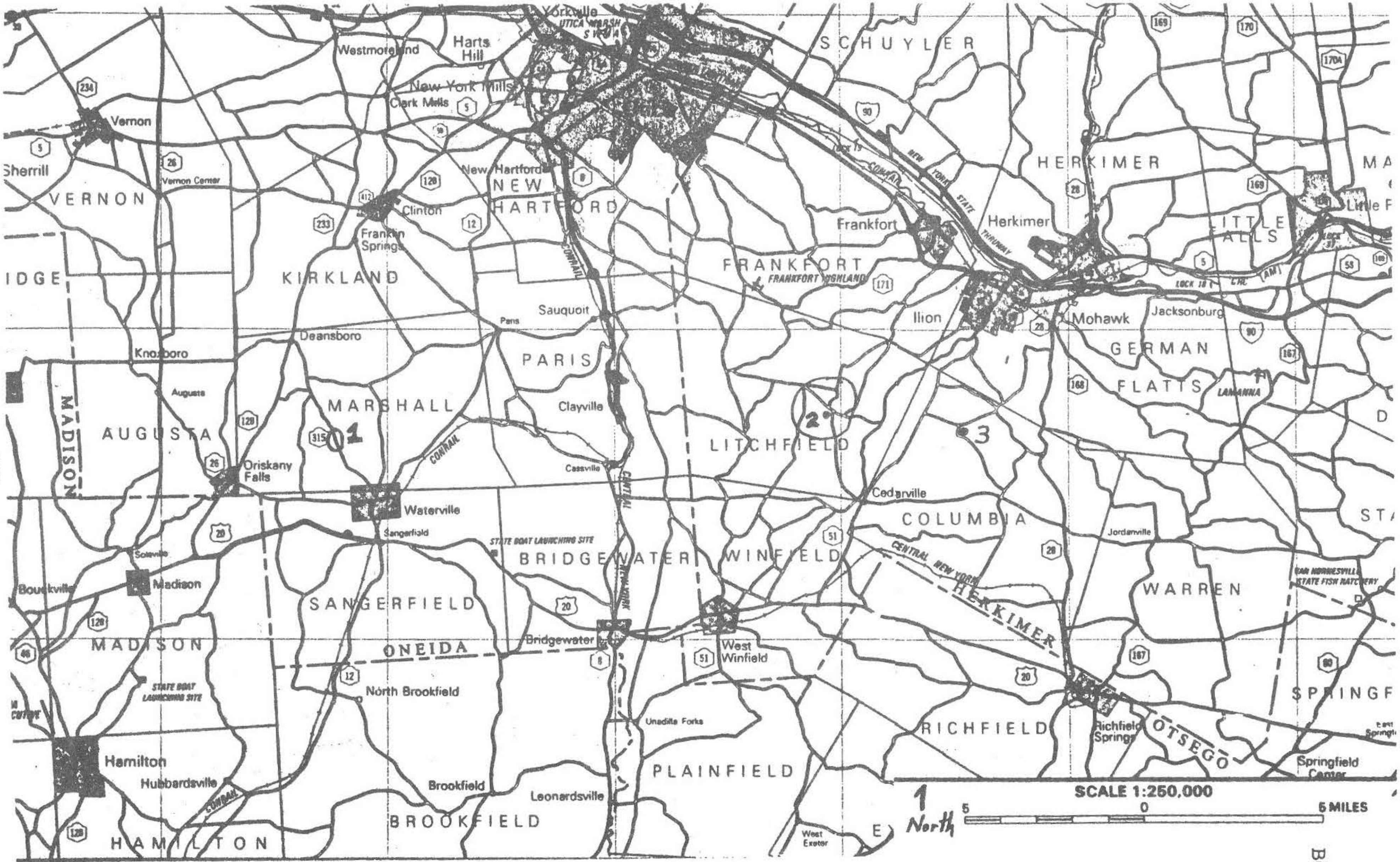
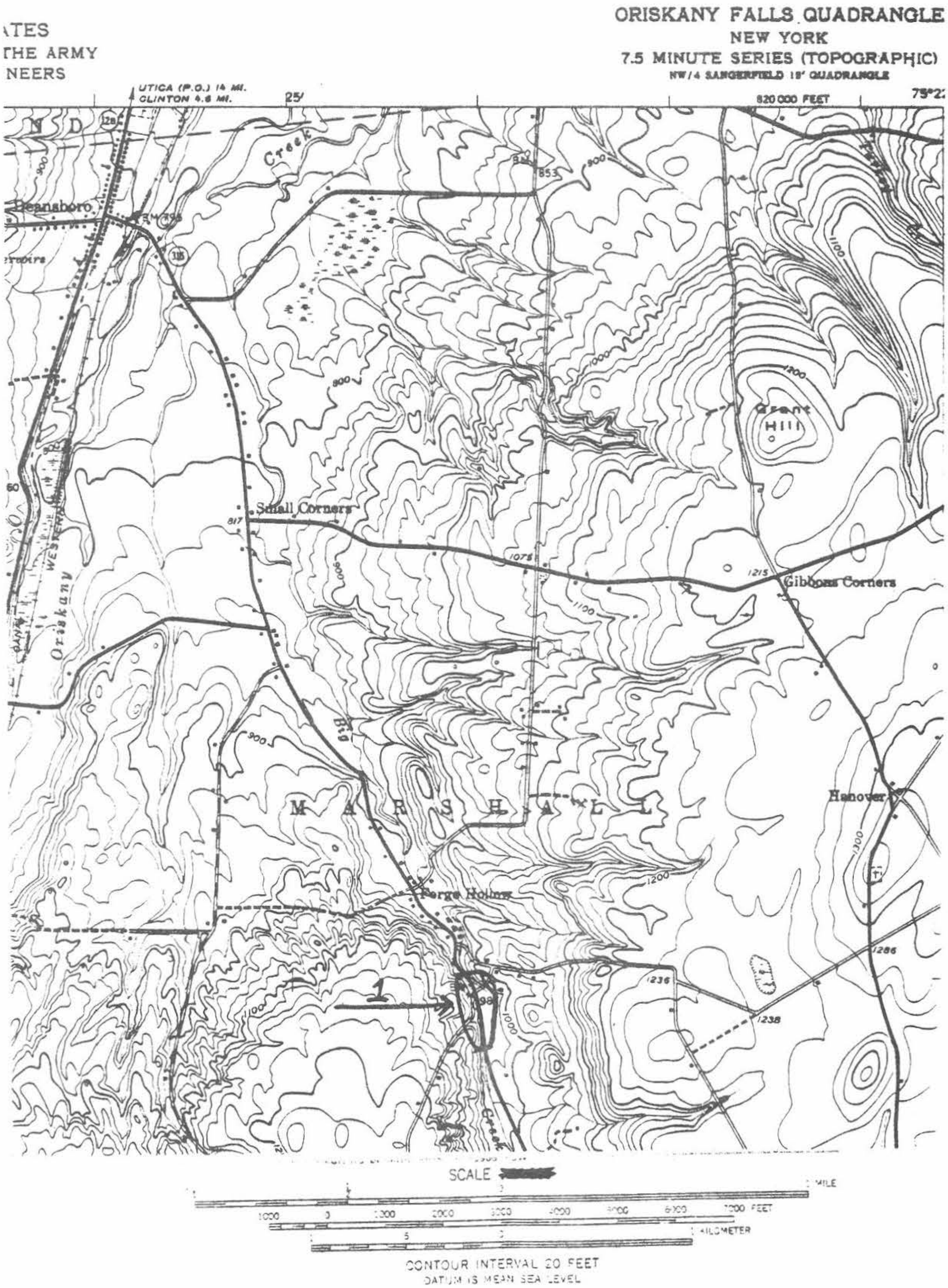

Yorkville
Utica Marsh
Westmoreland
Harts Hill
New York Mills
Clark Mills
SCHUYLER
Vernon
Sherrill
Vernon Center
VERNON
New Hartford
NEW HARTFORD
Clinton
Franklin Springs
KIRKLAND
Frankfort
FRANKFORT
Frankfort Highland
Herkimer
HERKIMER
LITTLE FALLS
Little F
Ilion
Mohawk
Jacksonburg
GERMAN FLATTS
Lamanna
Sauquoit
Pens
Deansboro
Knoxboro
PARIS
MARSHALL
Augusta
AUGUSTA
MADISON
Clayville
Cassville
LITCHFIELD
Oriskany Falls
Waterville
Sangerfield
Cedarville
COLUMBIA
Jordanville
State Boat Launching Site
BRIDGEWATER
WINFIELD
Central New York
HERKIMER
WARREN
Van Hornesville State Fish Hatchery
Solsville
Madison
Bouckville
SANGERFIELD
MADISON
ONEIDA
Bridgewater
West Winfield
North Brookfield
Unadilla Forks
RICHFIELD
Richfield Springs
OTSEGO
SPRINGF
Springfield Center
Hamilton
Hubbardsville
Brookfield
Leonardsville
PLAINFIELD
BROOKFIELD
HAMILTON
West Exeter
North
SCALE 1:250,000
5 0 5 MILES
1
2
3

Figure 13.



ORISKANY FALLS QUADRANGLE
NEW YORK
7.5 MINUTE SERIES (TOPOGRAPHIC)
UTICA (P.O.) 14 MI.
CLINTON 4.6 MI.
Creek
Deansboro
Small Corners
Gibbons Corners
Grant Hill
Oriskany
M A R S H A L L
Hanover
Forge Hollow
Big
Creek
1
SCALE
CONTOUR INTERVAL 20 FEET
DATUM IS MEAN SEA LEVEL

Figure 14.

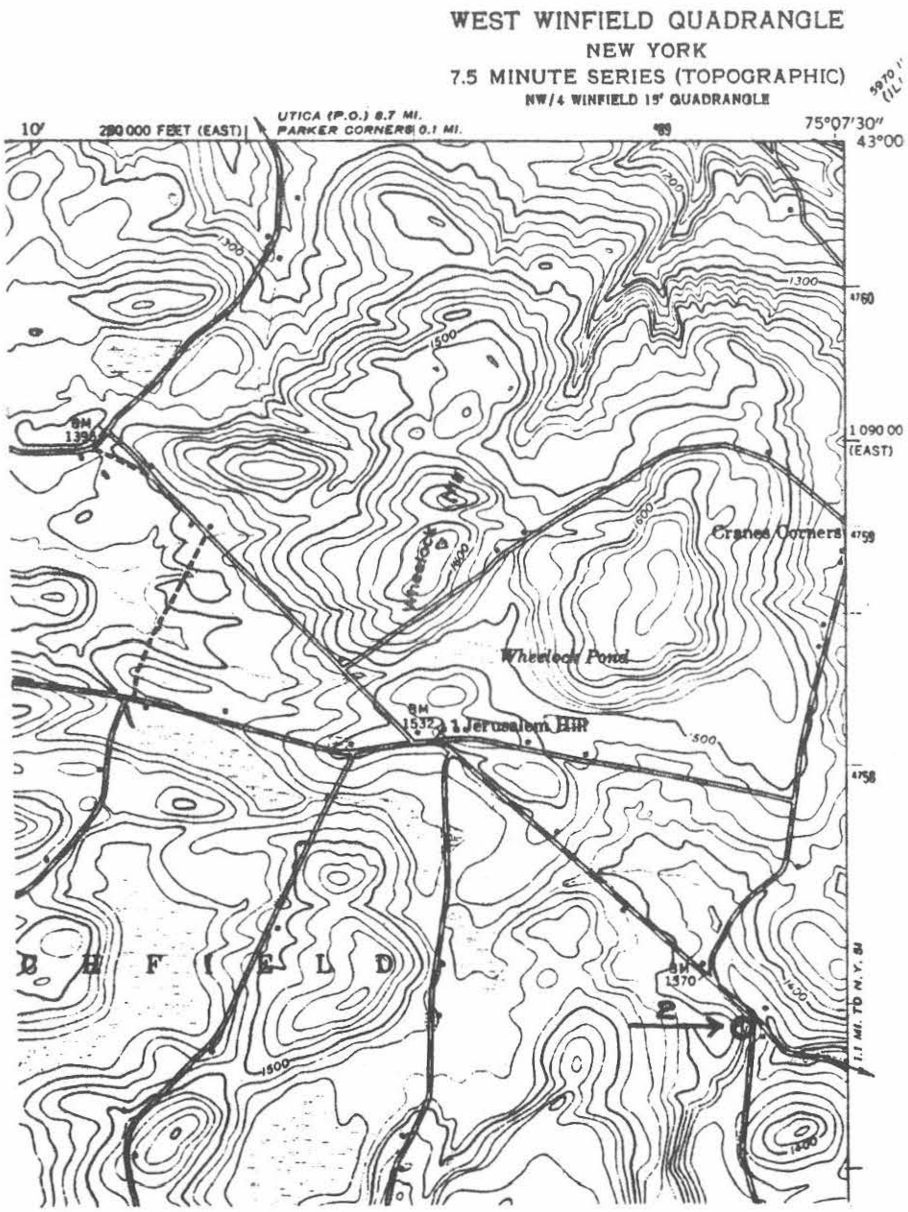


Figure 15a

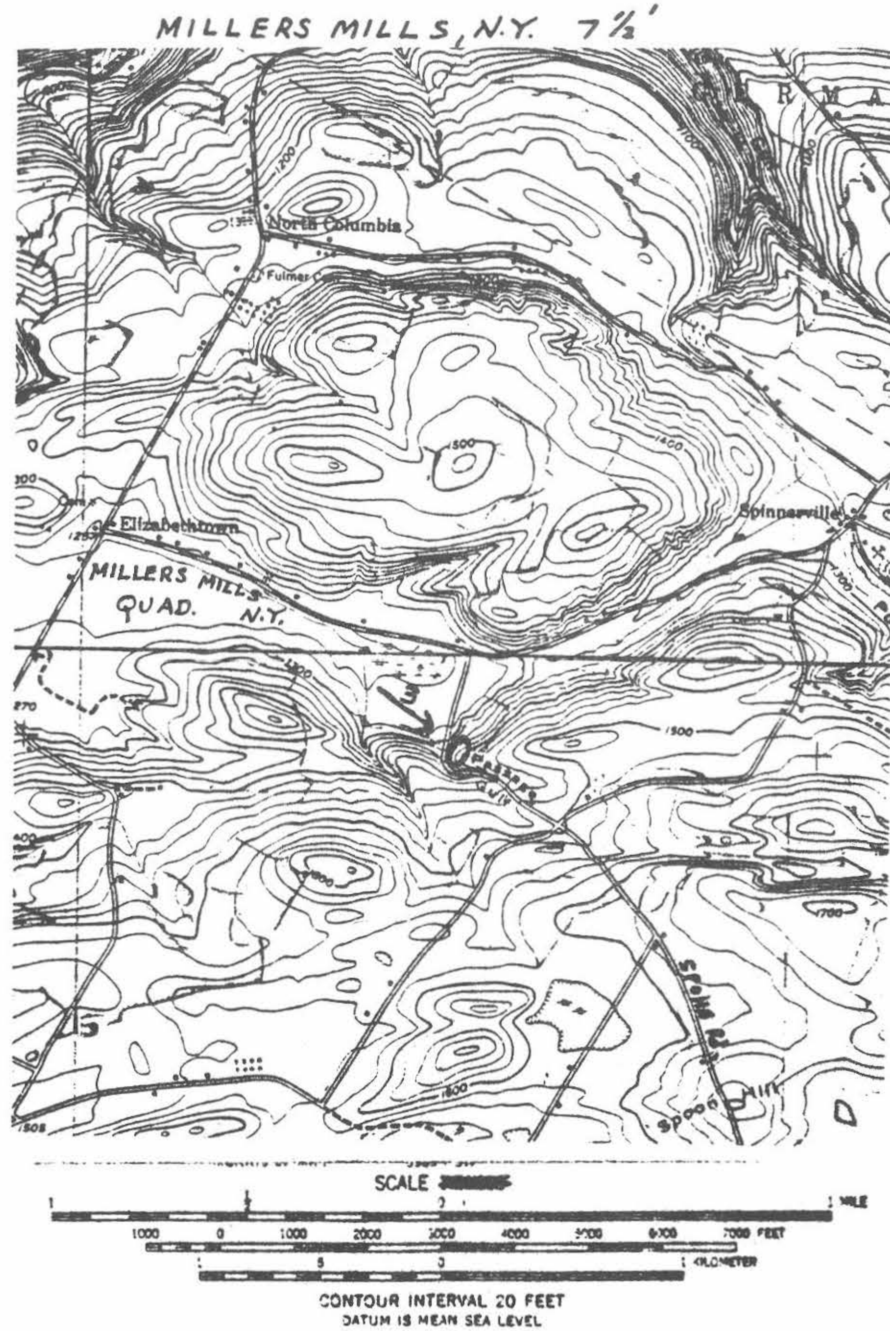


Figure 15b

BERTIE FORMATION ROAD LOG

Miles

0.0 Start at flashing light intersection of Rte. 233 and College Hill Rd. (412); bottom of Hamilton College Hill. Proceed south on Rte. 233 (Harding Rd.).

1.2 "T inters." with Rte. 12B, turn right.

3.7 Cemetery on left.

4.2 Village of Deansboro. Turn left onto Rte. 315 east.

4.5 Bridge over Oriskany Creek.

7.0 STOP 1 Outcrop on right. Big Creek on left. Parking on right.
Forge Hollow, New York, on Route 315 (fig. 14)
Oriskany Falls, N.Y., 7 1/2 minute topographic quadrangle
Rickard (1953) locality No. 43.

This locality is believed by Leutze (1959, p. 101-102) to be the Waterville outcrop cited by Vanuxem (1982) and Hall (1859). Rickard (1953, 1962) designated this site as the type locality for his Forge Hollow Member (= Scajaquada Member of present terminology).

This is the only complete sequence of the Bertie Formation in east-central New York. Both the lower and upper contacts with the Camillus and Cobleskill Formations, respectively are exposed. The lower contact is at the southern end of the exposure.

Fossils collecting is highly discouraged during this field trip because of the dangerous conditions at this outcrop (e.g., blind curve, narrow road, steep outcrop). KEEP OFF THE ROAD.

Nearly all faunal and sedimentary structural elements discussed in this paper have been found by the writers or reported by others as occurring here. The purpose of this stop, then, is examination of the fossils and sedimentary structures, as well as their stratigraphic sequence.

Continue south on Rte. 315.

9.4 Intersection of Buell (315) and Main St. W (Rte. 12) in Village of Waterville. Turn right onto Main St. W (Rte. 12).

Miles	
9.5	Continue on Rte. 12 (Sanger Ave.), left fork.
10.7	Rte. 20 intersection, turn left, east.
18.3	Intersection with Rte. 8, Bridgewater. Continue east on Rte. 20. Outwash plain.
21.4	Intersection with Rte. 51, West Winfield. Turn left onto Rte. 51 (North St.).
22.6	Proceed to stop sign at intersection of N. Winfield Rd. and Stone Rd. Continue on N. Winfield Rd.
23.7	Proceed on right fork at "Y inters.", Brace Rd.
25.4	Intersection of Brace Rd. and Babcock Hill Rd. Continue on Brace Rd. (now Berberick Rd.).
28.8	"T inters." with Jerusalem Hill Rd. Turn right onto Jerusalem Hill Rd.
29.8	STOP 2 Jerusalem Hill Rd. outcrop. Parking in lot of Town of Litchfield Town Hall, across from outcrop.

Jerusalem Hill, Litchfield, New York (fig. 15a)
West Winfield, N.Y. 7 1/2 minute topographic quadrangle Lautze (1959) locality No. 207

This locality is the Litchfield outcrop cited by Vanuxem (1842) Hall (1859), Clarke and Ruedemann (1912), and Ruedemann (1925). The wheelock Hill locality is located about 1 1/2 miles to the NW.

Although many eurypterids have been collected here in the past, NO collecting is authorized by the town board.

The purpose of this stop is to examine the geographic and stratigraphic continuity of the fossils and sedimentary structures with those seen at stop 1, located about 16 1/2 miles straight-line distance to the west of this stop.

Continue east on Jerusalem Hill Rd.

30.3	"Y inters.", continue on left fork (paved road).
30.4	Quarry on right. Camillus Formation, 80 feet exposed. STOP: Depends on time. (Ref. Treesh, 1972. Stop III).

Miles

Beckus Gulf. CAUTION, narrow road. Syracuse Formation, nearly complete section, (Treesh, 1972, Stop II).

31.3 "T inters." Rte. 51. Turn right, south. Vernon Shale on right, (Treesh, 1972, Stop I).

33.8 Cedarville. Intersection with Jordanville Rd. Turn left, east.

33.9 LUNCH. Ward A. Wheelock, Jr. Community Park, behind firehouse. Grocery, short walk up road.

Continue east on Jordanville Rd., past Rte. 51 south, to Columbia Center.

37.9 Intersection at Columbia Center. McKoons Rd. on right. Turn left onto Columbia Center Rd.

38.1 Spohn Rd., turn left.

After Brennan Rd. SLOW-CAUTION.

40.2 STOP 3 Passage Gulf (Spohn Rd.).

Stop 3 Passage Gulf, on Spohn Road (fig. 15b).
Millers Mills, N.Y. 7 1/4 minute topographic gradrangle
Rickard (1953) locality No. 39; Leutze (1959) locality No. 211.

This locality exposes an areally small outcrop, that is remarkably productive with regard to fossils. The upper-most beds of the Fiddlers Green Member are often excavated, giving the appearance of a battlefield. The farmer who owns the land at this locality has recently bulldozed off the top layers of a portion of this site.

The entire Fiddlers Green Member is easily accessible for detailed examination of the sedimentary structures and their stratigraphic sequence.

The purpose of this stop is to examine the continued geographic and stratigraphic continuity of fossils and sedimentary structures with those seen at stop 1, located about 20 miles straight-line distance to the west of this stop. Also, discussion is encouraged at this last stop relative to epeiric sea environments and the Bertie Formation.

For those intending to reach N.Y.S. Thruway. Continue down Spohn Rd. to "T inters." with Brewer Rd. Turn right to Hamlet of Spinnerville intersection. Turn right on Polly Miller Rd. to Rte. 28 intersection at Getman Corners. Turn left (north) onto Rte. 28 to Main St., Village of Mohawk. Turn right, watch for Thruway signs. About 9 miles from STOP 3.

Return to Hamilton College, Clinton, N.Y. and Utica. Backtrack south on Spohn Rd.

42.3 Columbia Center Rd. Turn right, south.

42.5 Jordanville Rd. intersection. Turn right, west.

46.0 Rte. 51 south, intersection, turn left, south.

49.2 Rte. 20 intersection, turn right onto Rte. 20, west. Flea market on right. Might be open, some bargains.

52.2 Village of West Winfield.

59.8 Village of Bridgewater. Rte. 8 intersection. Turn right onto Rte. 8, north to Utica and UTICA COLLEGE of Syracuse University.

63.6 Intersection with Rte. 12. Turn right, north onto Rte. 12 to Waterville.

64.9 Village of Waterville, center, turn left onto Buell Ave. (Rte. 315) at light.

Proceed on Rte. 315 to Deansboro.

70.2 "T inters." with Rte. 12B, Village of Deansboro. Turn right.

73.2 Rte. 233, turn left.

74.4 Intersection with College Hill Rd. stop sign and light. Turn left, up hill to Hamilton College. Turn right to Clinton, N.Y. Straight ahead to Rte. 5 intersection. Straight to Thruway. Left to Syracuse. Right to Utica <u>and</u> Utica College of Syracuse University.

END OF TRIP.