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WEST, Ronald Robert, 1935-
MARINE COMMUNITIES OF A PORTION OF THE WEWOKA FORMATION (PENNSYLVANIAN) IN HUGHES COUNTY, OKLAHOMA.

The University of Oklahoma, Ph.D., 1970
Geology

THE UNIVERSITY OF OKLAHOMA

GRADUATE COLLEGE

MARINE COMMUNITIES OF A PORTION OF THE WEWOKA FORMATION (PENNSYLVANIAN) IN HUGHES COUNTY, OKLAHOMA

A DISSERTATION

SUBMITTED TO THE GRADUATE FACULTY

in partial fulfillment of the requirements for the

degree of

DOCTOR OF PHILOSOPHY

BY

RONALD ROBERT WEST

Norman, Oklahoma

1970

MARINE COMMUNITIES OF A PORTION OF THE WEWOKA FORMATION (PENNSYLVANIAN) IN HUGHES COUNTY, OKLAHOMA

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ACKNOWLEDGMENTS

This investigation was carried out under the direction of Dr. P. K. Sutherland whose advice and supervision are gratefully acknowledged. Special thanks are due Dr. D. B. Kitts and Dr. C. W. Harper, Jr., who, throughout the course of this investigation, provided helpful suggestions and discussions. They also read the manuscript and offered suggestions for its improvement. The author is especially grateful to Dr. R. G. Johnson of the Department of Geophysical Sciences at the University of Chicago who critically appraised the manuscript and served as external examiner on the dissertation committee.

Dr. C. J. Mankin, Director of the School of Geology and Geophysics and of the Oklahoma Geological Survey provided constant aid and advice, particularly in regard to financial matters.

Studies conducted at the Marine Biological Laboratory at Woods Hole, Massachusetts, during the summer of 1968 were made possible by a National Institute of Health Fellowship and a travel grant from the University of Oklahoma, School of Geology and Geophysics.

The writer wishes to thank the National Science Foundation for providing funds for a 1968-69 traineeship for full time research and for funds to cover drafting and typing of the final manuscript; the School of Geology and Geophysics of the University of Oklahoma for providing funds for reproduction and other services connected with this study; and to my fellow graduate students, especially T. W. Henry, for suggestions and discussions provided throughout the course of the investigation.

This investigation was supported by research grants from the Society of the Sigma Xi and from the Penrose Fund of the Geological Society of America (Grant No. 1194-68). This support is gratefully acknowledged.

Lastly, and most importantly, this study could not have been brought to completion without the patience, encouragement and aid in the field, laboratory and office of my wife, Shirley L. West.

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INTRODUCTION

This investigation is a study of the community paleoecology of some fossil assemblages from the Desmoinesian rocks of Hughes County, Oklahoma. Community paleoecology is used as defined by Ager (1963, p. 181):

> . . . that is, with the study of the living community of the past, their relationships with their physical and chemical environment, and their interrelationships among themselves.

Assignment of depositional environments, while not the primary goal, is an essential part of this and any paleoecological study.

Purpose of Investigation

The main objectives of this study were: (1) to examine in detail the nature of the marine invertebrate fossil assemblages that occur in a thin stratigraphic interval within the Wewoka Formation in a limited geographic area; (2) to relate those organisms which were part of a fossil community or residual fossil community (Fagerstrom, 1964) by means of Q-mode cluster analysis and reconstruct the structure and composition of these benthic marine invertebrate communities; and (3) to relate these fossil invertebrate communities to their depositional environments.

Due to the limited area of this extremely detailed study it was not possible to arrive at any general conclusions regarding the paleobiogeography and evolution of the benthic communities. However, as additional studies of this type are made on stratigraphically equivalent units and units of different ages such interpretations may be possible. This is also true for the relationships of benthic invertebrate communities to Pennsylvanian paleogeography and cyclic sedimentation.

Previous Paleoecological Investigations

Most studies which have been termed "paleoecological" have for the most part treated depositional environments and are not truly paleoecological in nature. A few papers have appeared which have a more direct bearing on paleoecology. Those dealing with Paleozoic sediments will be considered briefly here.

Johnson (1962) presented a statistical method for recognizing distinctive associations of species and discussed the importance of this recognization in terms of geological and biological studies. Three associations from Pennsylvanian assemblages were defined and named: *Chonetina* association, *Orbiculoidea* association and Gastropod association. The *Chonetina* association being situated farthest offshore and the *Orbiculoidea* nearest shore with the Gastropod association intermediate in position. These same three associations were recognized at various stratigraphic horizons and were a reflection of the depositional environments of the lithologic units. The associations were interpreted as fossil communities but the various members of each were not related as to feeding type (suspension vs. deposit) or mode of life (infaunal vs. epifaunal). The important thing is that it could be shown that various associations of marine invertebrates of Pennsylvanian age could be related statistically to certain general depositional environments without years of collecting and subjective evaluation.

Olson (1961 and 1966) has discussed the aspect of food chains in regard to the origin of the mammals. He has shown how changes in the food chains of the Permian vertebrates might have lead to the trophic level relationships observed in the mammals today. As the food chains changed with time the structure of the vertebrate community more and more closely approached that of the present-day mammal communities. By studying the communities (food webs) of marine invertebrates some new light might be shed on the evolution of the various invertebrate groups.

The study by Zangrel and Richardson (1963) on the Mecca and Logan Quarry shales is a very comprehensive and exhaustive paleoecological study. The opening statement from the introduction (p. 3) states:

> The following study endeavours to analyze the forces and factors, both physical and biological, that produced the conditions leading to the formation of black carbonaceous shale deposits of Pennsylvanian age that contain tremendous concentrations of skeletons of vertebrates in association with invertebrates.

In 1964 Fagerstrom published a paper presenting criteria for the recognition of fossil communities. The term "fossil assemblage" was defined and subdivided into four types. These four types are: fossil community, residual fossil community, transported fossil assemblage and mixed fossil assemblage. In general the term "fossil assemblage" and the four types of such assemblages are used by the present author as defined by Fagerstrom in the 1964 article. However, the present author modifies the definition of residual fossil community in the section on benthic communities (p. 63).

Criteria presented by Fagerstrom were applied by him to a fossil assemblage from the Pennsylvanian of Nebraska but no attempt was made to discuss this assemblage in terms of feeding type or mode of life of the contained organisms.

Stevens (1966) considered what he called "fossil communities" of some Permian sediments in Nevada and Utah. The basis used for calling these fossil assemblages "communities" appears to be their mappability or the consistent and recurrent association of certain forms. The present author prefers to consider this too broad a use of the term "community" and suggests that the term biofacies be used.

In 1965 and 1968, Ziegler, and others, presented their ideas as to the composition and structure of marine invertebrate communities of the Lower Silurian rocks of Wales and the Welsh Borderland. They did not present the exact criteria that were used to demonstrate that these Lower Silurian assemblages were "life" assemblages. The interpretation that these fossils were in life position when collected appears to be the primary basis for the assumption that they were dealing with "life" assemblages. From detailed collecting and mapping of the occurrences of these Silurian forms it was possible to establish five benthic communities, each dominated and named for a brachiopod genus. These communities exhibit mappable distributions with the _Lingula_ Community nearest to the inferred shoreline and the _Clorinda_ Community farthest offshore. The composition of each community is presented in terms of the percentage that each species contributes to the whole and the nature of articulation and gross morphology. The structure, in terms of likely adaptations (i.e., feeding types), of each species is also presented and he (Ziegler) distinguished between epifaunal and infaunal elements. This study is especially important to biostratigraphic studies since it shows that the biostratigraphic zones of these rocks consist of the five benthic communities which appear and reappear in the section.

Fox (1968) in a study of the fossil invertebrates of Ordovician age in Indiana suggested that he was dealing with fossil communities. No evidence was presented which would indicate that the organisms studied were part of a fossil community. Until it can be demonstrated that the organisms studied represent life assemblages it is not, in the present author's opinion, possible to discuss communities. The mathematical technique used has potential usefulness in paleoecological studies. This is more of a biostratigraphical study, in that time trend analysis is used to define five zones based on the dominant pairs of brachiopod genera. Each such zone is further subdivided into "communities" by using R-mode cluster analysis. Stratigraphically and mathematically this is a significance study but biologically, and hence paleoecologically, it is not.

A recently published work of Bretsky (1969) concerns Ordovician fossil assemblages. The basis for establishment of communities in this study is the consistent and recurrent association of species. There is no doubt that this is an important and useful concept but is it enough? To use this concept of marine ecology where one is dealing with living forms is one thing. To use the same concept alone for fossil assemblages without some methods of determining the amount of transportation is something different. Consistent and recurrent associations of organisms could characterize transported as well as non-transported fossil assemblages. There is some evidence (Boucot, 1953; Johnson, 1965; Hallam, 1967; and Warme, 1969) that there is little difference between the composition of live and dead mollusk assemblages; more investigations of this type are needed.

Methods of Investigation

The methods of investigation used here can be divided into four main groups: (1) criteria for determining the nature of a fossil assemblage; (2) selection of a stratigraphic unit and field methods; (3) laboratory procedures and (4) statistical methods. Each of these will be considered separately.

Criteria for Determining the Nature of Fossil Assemblages

There are a number of criteria for determining whether or not marine invertebrates are members of a fossil community or residual fossil community (Fagerstrom, 1964). These criteria have been listed and discussed by Fagerstrom (1964, p. 1200-1205) and only selected ones will be considered here. His list is as follows: size-frequency distributions; ratio of articulated to disarticulated valves; ratio of opposite valves; dispersion of fossils; population density; community density; faunal composition and diversity; orientation of clastic particles (including fossils); texture, sorting and structure of sedimentary aggregates; lithofacies relationships; surface condition of fossils and ratio of whole to fragmented shells. Criteria used in this paper are:

(1) percentage of articulation; (2) percentage of opposite valves; (3) percentage of broken (not crushed) specimens; (4) position of fossils within the matrix; (5) nature of fossil preservation and (6) size-frequency distributions. To some extent the dispersion of fossils, population density and assemblage composition and diversity were also used. The first three criteria are straightforward and only the latter three will be discussed.

Position of Fossils in the Matrix. By carefully collecting in-place fossils it is possible to obtain some idea of the relationship of the organism to the bedding of the lithologic unit. Whether or not a fossil is in a life position can often be decided by looking at the life habits and positions of morphologically similar and taxonomically related forms living today. A well known example is the inarticulate brachiopod *Lingula* which lives in a vertical burrow.

Other invertebrates provide less well documented examples. Nuculoid pelecypods are interpreted by Stanley (1968) as infaunal labial-palp deposit feeders. Generally the beak of these bivalves is pointed upward toward the sediment-water interface. Fossil forms in a shale/claystone with their beaks pointed upward with respect to bedding could be interpreted as being in, or near life position (pl. IV, fig. 20).

Nature of Fossil Preservation. A careful examination of the nature of preservation and the degree of abrasion may provide clues as to the amount of transportation involved in the formation of any particular fossil assemblage. Aspects such as percentage of articulated forms, percentage of opposite valves in bivalves and the percentage of broken forms may also give some indication of the amount of energy that was available within the environment for abrasion and transportation. If these effects are the result of transportation it does not necessarily mean that the organisms were removed from their life associations. Such associations could cover large areas (thousands of square miles) or members of geographically smaller areas would not have to be transported very far to exhibit the effects. Also these same effects could be the result of purely biological factors (i.e., predators and/or scavengers).

Fossils with delicate surface ornamentation and thin shells will be especially susceptible to abrasion and breakage (i.e., productid brachiopod shells with long hollow spines). If in pelecypods the percentage of articulated specimens is high it is plausible to infer that they are part of a fossil community or residual fossil community (Fagerstrom, 1964). The valves in lamellibranchs are held together by the ligament and adductor muscles. Upon death of the individual these tissues decay and the valves disarticulate. If the clams are infaunal, or epifaunal and buried quickly after death, the valves might be held together by the confining sediment. If the dead infaunal forms were uncovered or the epifaunal forms were not buried rapidly then the valves would disarticulate. In this case equal, or near equal, numbers of opposite valves would be a good indication that the organisms were members of a fossil community or residual fossil community.

The same is true for the brachiopods. In the articulates the mechanism for opening and closing the valves is muscular action but with the aid of the calcareous hinge processes of each valve. This more sturdy hingement is probably responsible for the rather high percentage of articulate brachiopods in most fossil assemblages.

Unfortunately these criteria do not always provide the answers sought by the paleoecologist. Often the fossil forms do not have any closely related (taxonomically) living forms so that the nature of their life positions with respect to the substratum cannot be inferred. Or, as a result of evolution, there is little morphological similarity between the living and fossil forms which would indicate differences in life habits and other ecological requirements. A large number of fossil organisms contained in the Wewoka Formation possess relatively smooth shells with very little or no ornamentation. Therefore, it is not possible to determine from an examination of the nature of the skeletal preservation how effective transportation has been in the formation of the fossil assemblages. Regarding fragmentation and similar alterations of invertebrate shells it is important to point out that some of this alteration may be due to predators, scavengers and encrusting symbionts. Fagerstrom (1964, p. 1205) states:

> These alterations may appear as chipped, cracked, or scratched edges of the shells of both predator and prey and drilled holes or pits in the shells of the prey or host. . . . Extreme selective predation or scavenging could alter the form of the size-frequency distribution, could cause the disarticulation of nearly every bivalve, or could cause the fragmentation of one valve of some species. Some hosts or predators may even be agents of transportation.

The effects of predation on bivalved molluscs is summarized in a paper by Carter (1968). This is a significant factor and its importance should not be overlooked in paleoecological studies.

Size-Frequency Distributions. Determination of the mode of formation of fossil assemblages is greatly facilitated by a consideration of size-frequency distributions. Olson (1957) showed that by combining the slow growth rate curve (fig. 1A) of invertebrates with their mortality curve (fig. 1C) it is possible to characterize members of a fossil community in terms of size-frequency distributions. If the invertebrates were members of a fossil community then their size-frequency distribution should be positively (right) skewed (fig. 1D). Percival (1944, fig. 1); Rowell (1960, figs. 1 and 2); and Rickwood (1968, fig. 2) show that such a distribution is right-skewed when it is based on a direct census of the standing crop of some species of perennial marine invertebrates. A distribution of this shape is due to the interaction between high natality and high infant mortality rates. Studies by Deevey (1947, p. 312; 1950, p. 58-59) and Paine (1963, fig. 17) show that the positively skewed distribution is similar in shape to survivorship curves known for a few species of marine invertebrates. Use of these distributions has been made by paleontologists (Boucot, 1953, p. 26-31; Veevers, 1959, p. 891 and Fagerstrom, 1964, figs. 4 and 5) in recognizing members of fossil communities.

The validity of the shape of Olson's (1957) growth curve is supported by experimental evidence obtained by Weymouth and Thompson (1931) for the pelecypod _Cardium corbis_. The growth curve derived from this experimental evidence is shown in Figure 1B. Shape of the mortality curve (fig. 1C) is characteristic of organisms which have large numbers of planktonic larvae (Fagerstrom, 1964, p. 1200-1201). The mortality rate is highest at the termination of parental care. In most invertebrates this is the time from the moment of fertilization to larval settlement or until a certain maximum size is reached. This latter point may correspond to the formation of an adequate skeleton. Naturally there

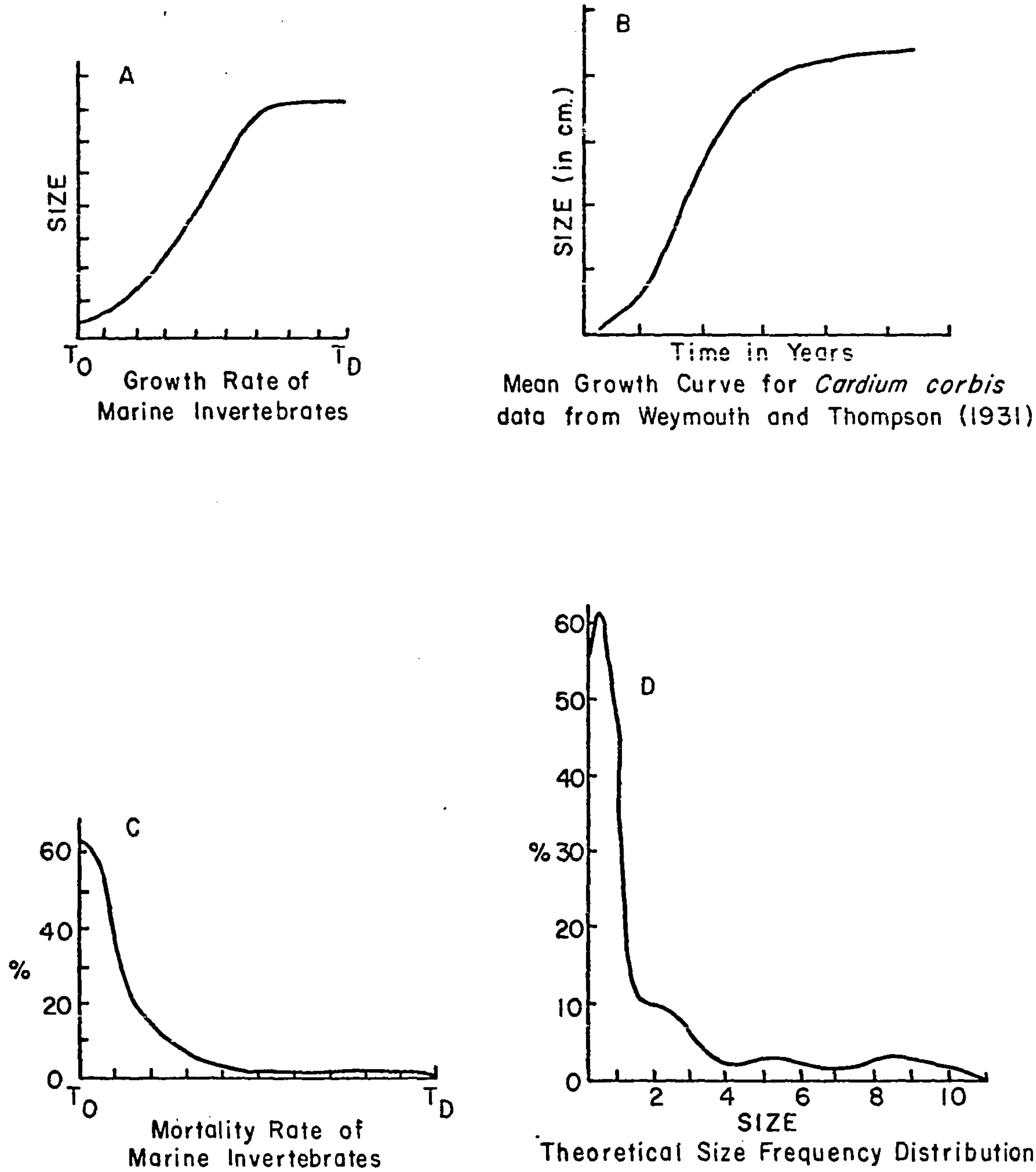


Figure 1. Growth, mortality and theoretical size-frequency curves for marine invertebrates. T_O, time of natality (or time of appearance of first preservable parts); T_D, time of maximum life span of species (death); size based on a gross measure (adapted and modified from Olson, 1957).

is going to be high mortality of the germ cells prior to fertilization, since fertilization takes place more or less at random in the open sea. Only the potential adults and their early mortality are of interest and there are no potential adults until fertilization is complete.

As mentioned above there are examples of positively skewed size-frequency distributions of present-day marine invertebrates. However, it seemed desirable to look at a Recent marine invertebrate that has the same basic morphology as its presumed Paleozoic ancestors before applying this method directly to fossil assemblages. The author had the opportunity to make such a study while at the Marine Biological Laboratory in Woods Hole, Massachusetts, during the summer of 1968. This study is being published by the Marine Biological Laboratory and is in press at this time. Only the results relevant to this study will be considered briefly here.

The pelecypod Nucula annularis was selected for this study. It occurs in great numbers in the bottom sediments of Buzzards Bay and has possible Paleozoic, specifically Pennsylvanian, ancestors which occur in great abundance in the claystone sediments of the Mid-Continent. These organisms are infaunal labial-palp deposit feeders (Stanley, 1968, fig. 3). Benthic studies of Buzzards Bay have been made by Sanders (1958; 1960). According to these studies the bottom sediments in the bay are of two types, mud and sand. Each bottom type is characterized by distinct biotic elements. Specimens of Nucula annularis were obtained from a dredge sample of bottom sediments from Sander's Station R. This station is located in one of the areas with a mud bottom and is dominated by the polychaete worm Nephthy incisa and the lamellibranch Nucula annularis.

From this dredged sample a subsample of 30 cubic centimeters of mud was selected and all the specimens of Nucula annularis were removed and sized. The resulting size-frequency distribution was positively skewed (fig. 2).

The length and height of 300 specimens were obtained and the number of major growth lines counted. These parameters were plotted against frequency. From the length/frequency plot it was possible to distinguish three separate classes of individuals. These classes were shown to correspond to possible "age" classes based on the mean number of growth lines per class (West, 1969).

To investigate the rate of growth the length was plotted against the height for each of the three "age" classes. Regression lines were calculated and drawn for each of these three "age" classes. The form of the linear regression equation used was $H = b + aL$ where H and L are the height and length respectively, a and b are the growth ratio and initial growth index as given by Imbrie (1956, p. 234). Mathematically these are the slope of the regression line and the y-intercept respectively. Regression analysis of the three classes indicates that growth is allometric and is slightly different for each of the "age" classes. Regression lines for two of the three classes are shown in Figure 3. Other investigations have shown that in bivalve growth the relationships between two parameters of the organism will follow a simple allometric association for a limited time, but over extended periods multiple relations occur as indicated by the changes in slope of the regression lines (Wilber & Owen, 1964, p. 214, fig. 2). The association of regression lines for two of the classes of Nucula

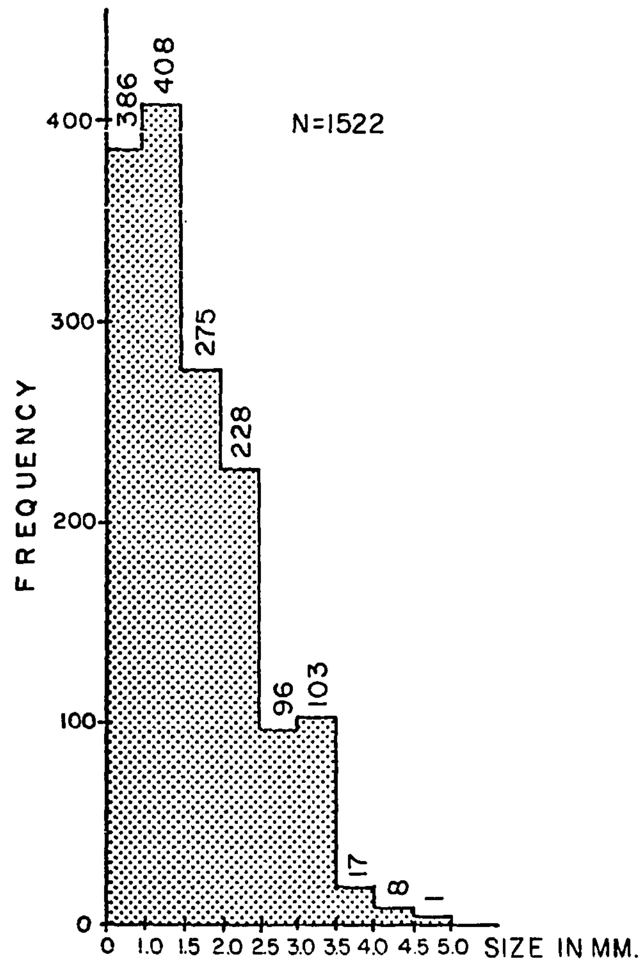
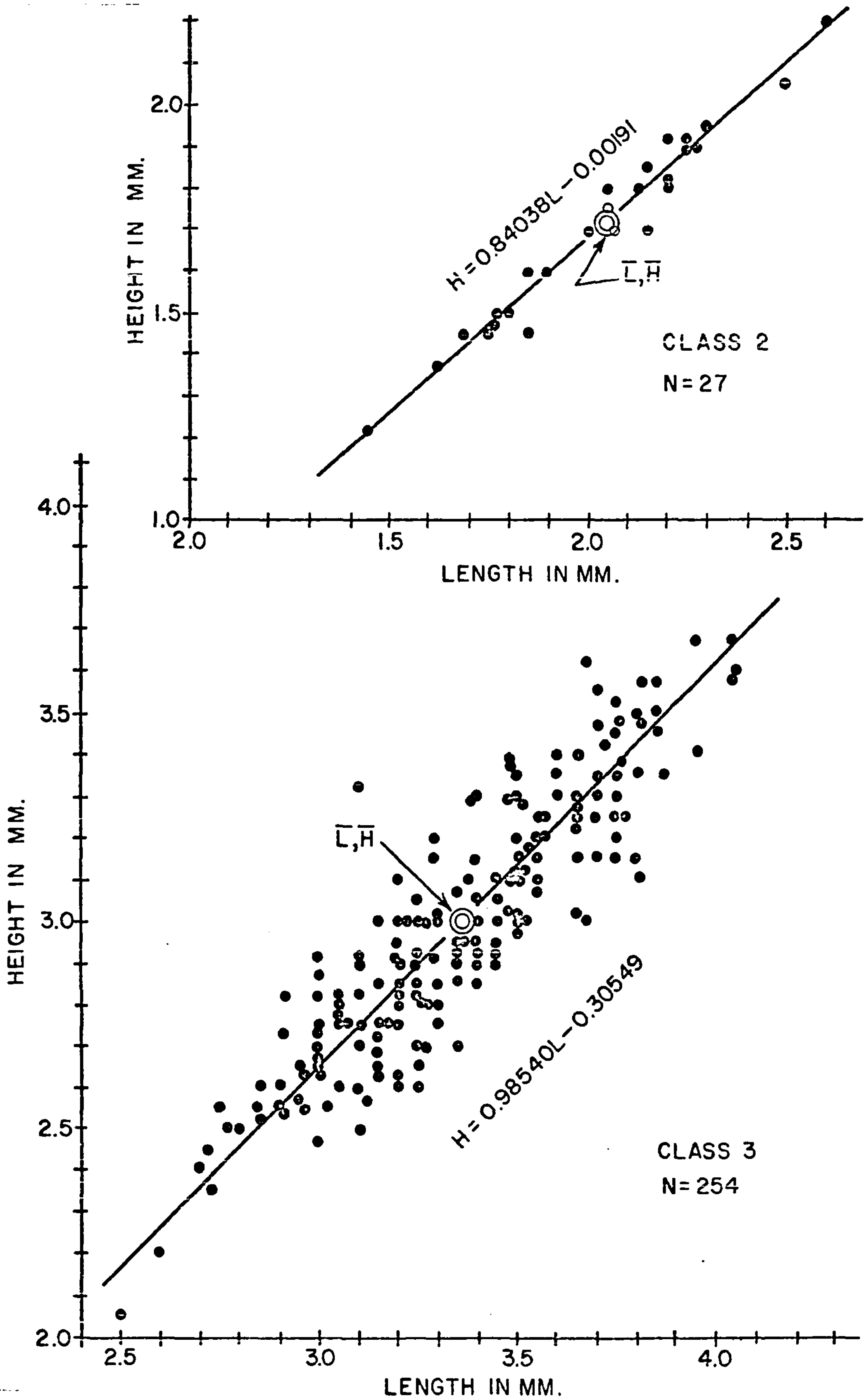


Figure 2. Size-frequency distribution of Nucula annularis (from West, 1969, fig. 2A).

Figure 3. Regression lines for classes 2 and 3 of Nucula annularis. $\bar{L}$, mean length; $\bar{H}$, mean height; N, total numbers of individuals per class (modified from West, 1969, figs. 5B and 5C).


HEIGHT IN MM.
H=0.84038L-0.00191
L̄,H̄
CLASS 2
N=27
LENGTH IN MM.
HEIGHT IN MM.
L̄,H̄
H=0.98540L-0.30549
CLASS 3
N=254
LENGTH IN MM.

annularis are shown in Figure 4. These are the same regression lines illustrated in Figure 3. The change is slight, but nevertheless, it is consistent with Oldon's 1957 idea of slow growth in marine invertebrates and also with the experimental data of Figure 1B.

No data are available on the rate of juvenile mortality in this organism. It is a safe assumption that infant mortality is high, particularly since the organism has a planktonic larval stage. A slow growth rate has been shown to be possible for Nucula annularis. The resulting positively skewed size-frequency distribution appears to be due to a combination of this slow growth rate and high juvenile mortality.

In using size-frequency distributions as a criteria for determining the nature of a fossil assemblage it is important to remember that such a distribution is the result of many individual fossil populations. That is, it is a composite of many, perhaps thousands, of individual populations of a particular species of invertebrate and not of a single population. This is a critical point when considering the comparison of size-frequency distributions of present-day invertebrates with the same distributions of fossil invertebrates. No matter how carefully the fossil collections are made it is not possible to get a sample from one single population as it is for Recent invertebrates.

The use of size-frequency distributions alone may not be effective due to the absence of individuals of one or more size-classes. Absence of individuals may be due to sampling bias, transportation, low mortality, recruitment failure and/or selective predation which selectively removed certain size classes. Solution by interstitial or other circulating waters may selectively dissolve certain shells. Shells of

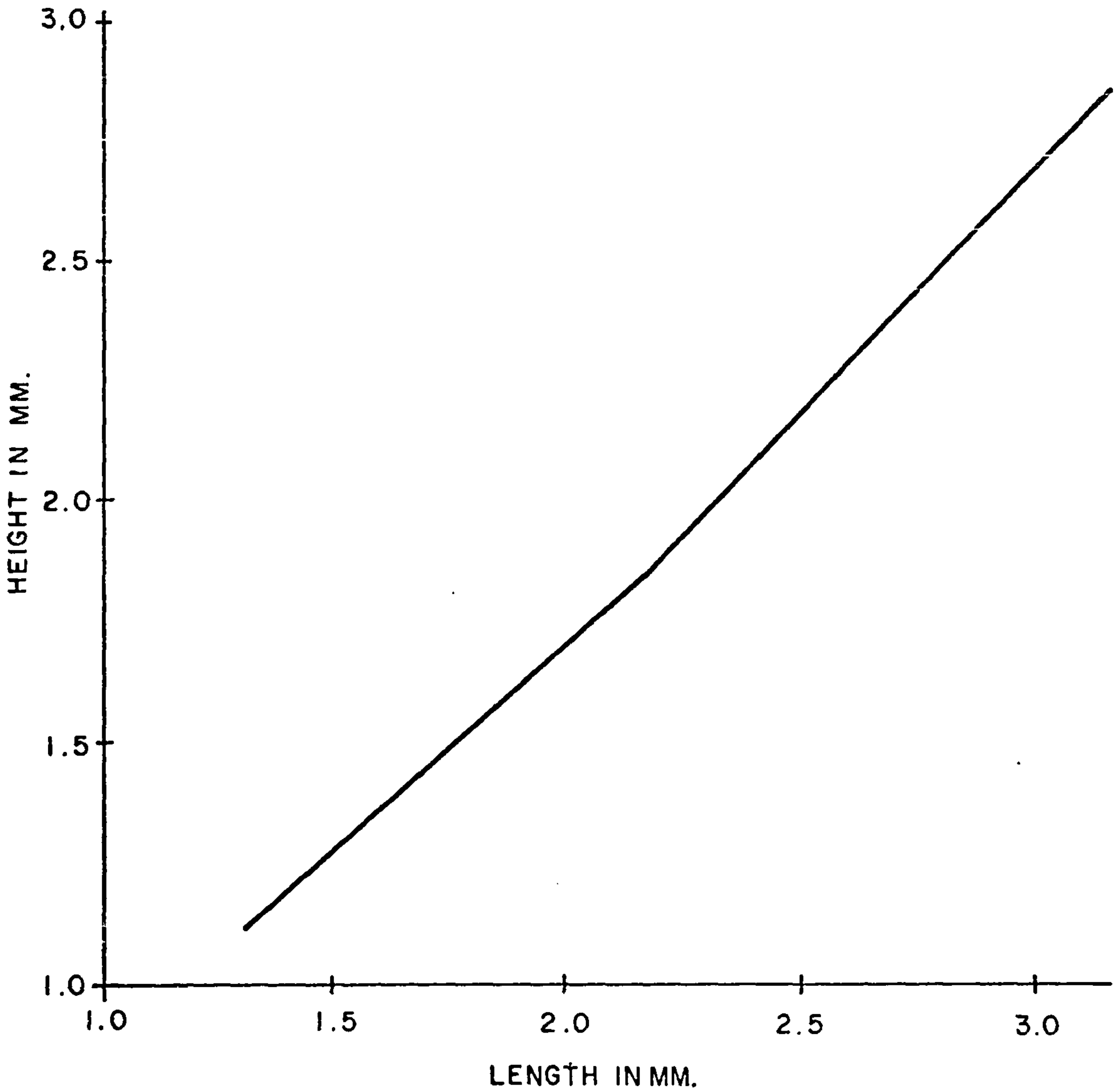


Figure 4. Combination of regression lines of classes 2 and 3 (fig. 3) for Nucula annularis.

smaller individuals are particularly susceptible to solution since they are thinner than the larger, thicker "adult" shells. That such solution of calcareous skeletons can and does occur has been demonstrated by Chave (1964, p. 377-387).

Using all the criteria indicated previously an attempt was made to reconstruct the nature and composition of benthic marine communities of a portion of the Wewoka Formation in Hughes County, Oklahoma.

Selection of the Stratigraphic Unit and Field Methods

The Wewoka Formation was selected because it contains fossil assemblages dominated by molluscans (Girty, 1915). Because of the detailed nature of the investigation only a portion of the total Wewoka in a small geographic area was chosen. The stratigraphic position of the Wewoka and its northern equivalents are shown in Figure 5.

An assemblage that was dominated by molluscans was desired because the ecological requirements of the various mollusk genera could be inferred from taxonomically similar genera which are living today, i.e., the nuculoid pelecypods. By studying a fossil assemblage that is dominated by molluscans with presumed present-day descendants it has been possible to make some inferences as to the ecological requirements of certain associated fossil forms, such as the brachiopods.

Most of the collections considered by Girty (1915) were from the Wewoka Quadrangle, in an area now forming part of Hughes County. Figure 6 is a map of Hughes County, Oklahoma, showing the outcrop pattern of the Wewoka and the position of the county within the State of Oklahoma. Initial reconnaissance work centered around this area in hopes of locating Girty's exact localities. Numerous small shale/claystone samples

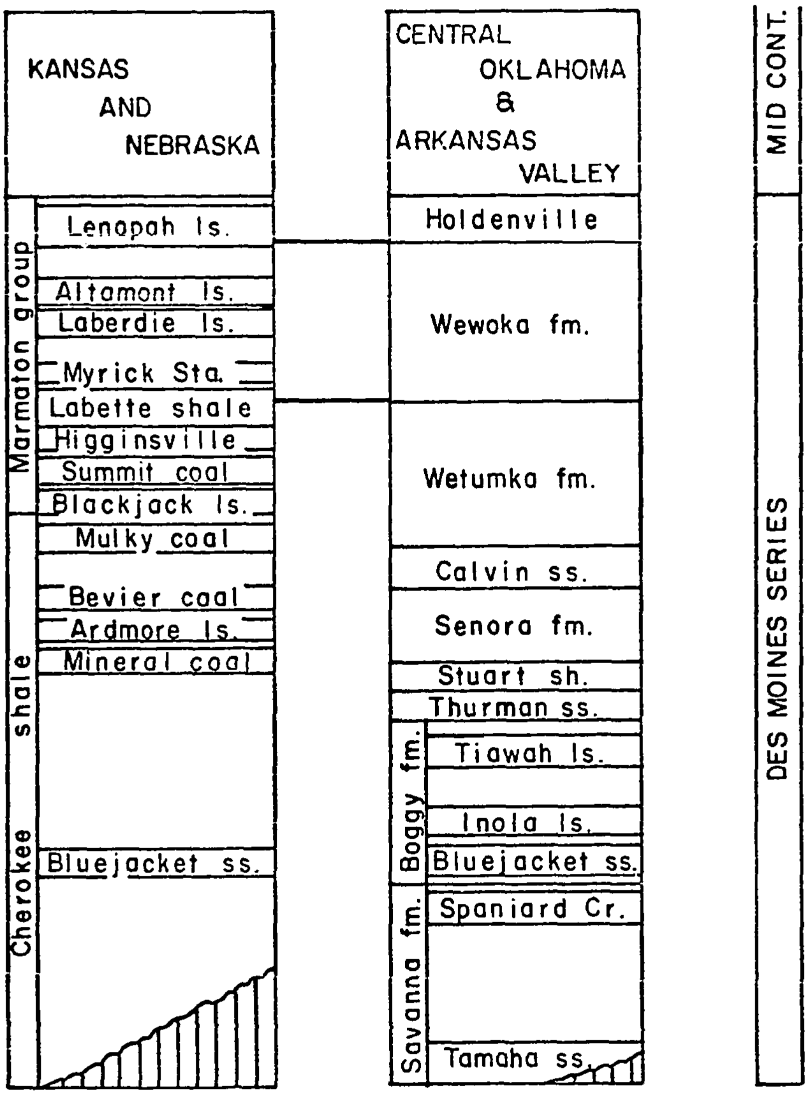


Figure 5. Stratigraphic sections of rocks of the Des Moines Series in Oklahoma, Kansas and Nebraska (modified from Moore, et al., 1944).

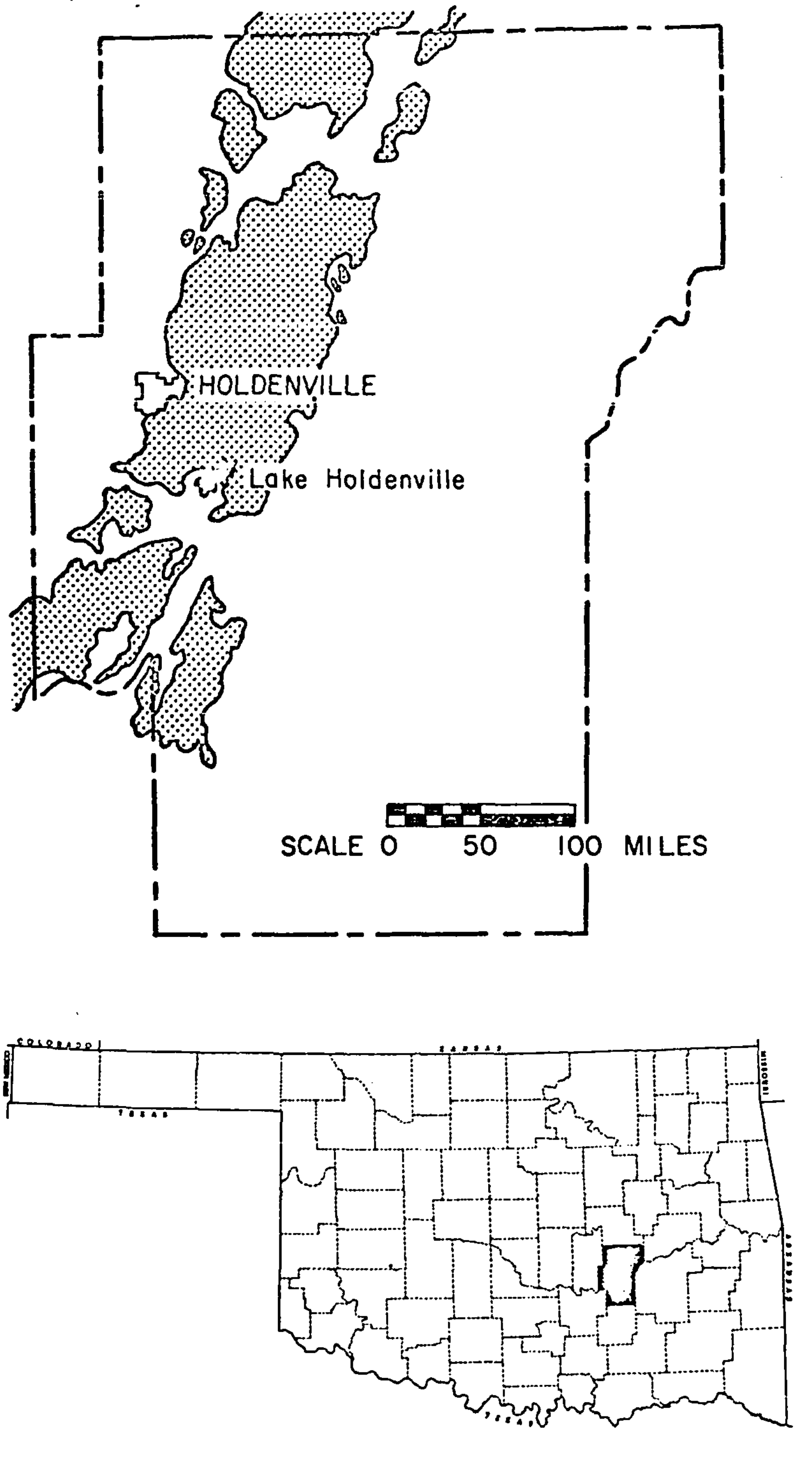


Figure 6. Outcrop pattern of the Wewoka Formation in Hughes County, Oklahoma (after Miser, et al., 1954).

from various localities were collected and processed to determine the abundance and diversity of the contained fossil assemblages. Fortunately Weaver (1954) had prepared a geologic map of Hughes County which greatly facilitated this phase of the study. With the aid of this map, the Oklahoma Highway Department map of the county, the old topographic map of the Wewoka Quadrangle and aerial photographs, two of Girty's collecting sites were located. These are Girty's localities 2006 and 2010 (1915, p. 271). At both of these localities the exposures were measured and some fossil collections obtained. Unfortunately they exposed different portions of the Wewoka Formation as mapped by Weaver (1954) and were not suitable for this study.

An area was selected in Sec. 33, T. 7 N., R. 9 E., of Hughes County, Oklahoma. This area is located on the northwest side of Lake Holdenville and southeast of the town of Holdenville. Figure 7 shows the area as well as the two Girty localities and a third exposure, locality J.

The area can be referred to as the west half of the NW$\frac{1}{4}$, Sec. 33, T. 7 N., R. 9 E., Hughes County, Oklahoma. Some of the measured sections extend outside of this area but most are confined within it. Exposures are of the Pwk-3a sandstone and the shale/claystone below it. The shale/claystone interval selected is below the beds exposed at Girty's locality 2006 and above the beds exposed at his locality 2010. Shale/claystone below sandstone Pwk-3b is exposed at locality 2006 and the same type of lithology below sandstone Pwk-2 is exposed at locality 2010 (see fig. 7). Locality J is included because it is the only place where the nature of the contact between Pwk-3a and the underlying shale/claystone can be observed.

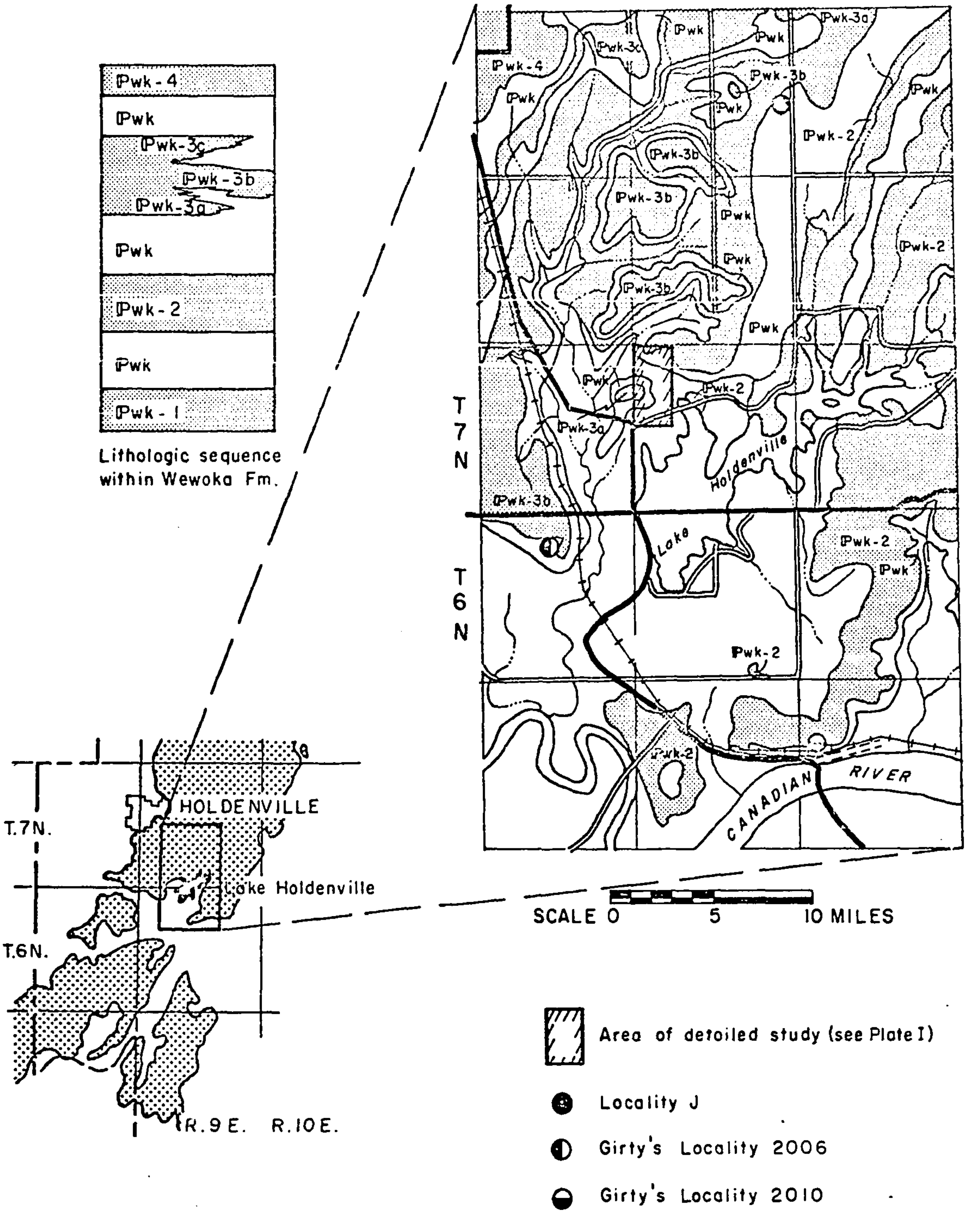


Figure 7. Pennsylvanian (Wewoka) geology and localities of shale/ claystone exposures studied in Hughes County, Oklahoma (modified from Weaver, 1954).

The study area is dissected by a stream which drains the overflow from Lake Holdenville. Rather continuous exposures of various portions of the shale/claystone interval occur along this tream. Within the area are three hillside glades (Sections E, F and G) which provide additional outcrops.

The only topographic map available of this area of Oklahoma is the 1900 Wewoka Quadrangle. It was necessary to prepare a detailed contour map of the area to provide a topographic framework for the investigation. This map was prepared by using an alidade and plane table.

The elevation of the center of the west line of Sec. 33, T. 7 N., R. 9 E., was established with an altimeter. Bench marks at the southwest corner of Sec. 31, T. 7 N., R. 9 E., and at the southeast corner of Sec. 36, T. 7 N., R. 9 E., were used to establish this elevation. By calibrating the altimeter at each of these two bench marks at different times and under different atmospheric conditions and taking an average of 12 to 15 readings at the point of unknown elevation a usable elevation was obtained. The average elevation determined from the 12 to 15 readings was 805.0 feet. This served as the main base station for the plane table mapping. A total of 20 wooden stakes were located at strategic positions within the area to serve as additional elevation reference points to aid in mapping and in measurement of stratigraphic sections. The elevations of the 20 points were established by using the main base station, alidade and plane table.

Stratigraphic sections were measured to establish a stratigraphic framework for the investigation. Eight such sections were measured (A through H) using tape, hand level and jacob staff and/or alidade and plane table. The exposure at locality A' was used to supplement the data for that horizon at measured section A. Elevations at the top and base of each of the sections was established using the 20 reference points. Besides locating the base and top of each section in the standard legal manner; they were also recorded as the distance and bearing from three reference points. These reference points are, in the order recorded:

1) Center of the west line of Sec. 33, T. 7 N., R. 9 E.
2) Center of the W.P.A. dam which is 104.0' due south of the center of the NW$\frac{1}{4}$, Sec. 33, T. 7 N., R. 9 E.
3) Center of the NW$\frac{1}{4}$, Sec. 33, T. 7 N., R. 9 E.

Section measuring involved, besides recording the thickness and nature of the lithologic units, the collection of float samples of fossils and also composite samples of the various lithologic units. Float samples were collected for every five foot or smaller interval along the entire length of each measured section. Composite samples were collected for every five foot exposed interval or every lithologic change, whichever came first. During the laboratory study of the composite samples some of the five foot interval samples were combined. Most were treated separately to obtain an impression of the succession of the organisms and the subtle lithologic changes in each section. During all phases of the study particular attention was paid to the position of the fossils in the matrix; their orientation along bedding planes where possible; tracks, trails and other ichnofossils; association with other forms and the nature of preservation.

The eight measured sections provided the necessary stratigraphic framework within which to collect samples for use in establishing the nature of the fossil assemblages present. Because the lithologic units are laterally non-persistent it is not possible to relate the eight sections on a strictly lithologic basis. The basic stratigraphic relationship was based upon elevation and dip (1° NW, Weaver, 1954, p. 60). A preliminary structural cross section was constructed in order to locate collecting stations at equivalent horizons in each section. Nineteen collecting stations were selected in five of the eight measured sections. The fossils of this shale/claystone are more or less evenly distributed throughout the interval and are not limited to thin highly fossiliferous horizons. Hence, selection of the stations was governed by available exposures. It was necessary to have as many laterally equivalent stations as possible. To obtain them a trial and error method had to be used until the greatest number could be located. These 19 stations represent five different horizons and are located in relation to the three reference points listed above with distances and bearings (Appendix II). From each of the 19 stations three samples were collected: (1) approximately 100 pounds of shale/claystone for paleontological and paleoecological study; (2) a much smaller sample for mineralogical analysis; and (3) an intermediate sized sample for palynological study. All three types of samples were collected so that only in-place, unweathered material was obtained. Each sample was to represent as thin a layer as possible, so the interval sampled was not more than 5 centimeters thick.

Laboratory Methods

A total of 177 samples was collected from the eight measured sections. Of these, 34 were samples of fossil float and the remaining 143 were lithology (composite) samples. An additional five samples were also collected, one from Locality J and two each from Girty's localities 2006 and 2010.

Fossils from the 34 float samples were washed, sorted, identified and counted. The 143 lithologic composite samples were examined with a binocular microscope and described as to color, lithology, accessory minerals and observable fossil content. Of these samples, 122 were shale and/or claystone. These 122 samples were prepared and the residues examined microscopically. Preparation of the samples involved through drying in an oven, soaking the dry sample in kerosene for approximately 24 hours, pouring off the solvent and adding hot water, soaking in hot water for an additional 24 hours, washing the disaggregated sample through a 200 mesh (3.75 ϕ) sieve with a jet of hot water and drying the material retained on the sieve. The fossils in these residues were identified as to genus, in some cases species, and an estimate made of the total number referable to each taxonomic category. Inorganic constituents were noted as to composition and relative abundance. Polished and etched surfaces, as well as acetate peels, of the calcareous and sideritic nodular horizons (21 samples) were prepared and studied in conjunction with the lithologic descriptions. Appendix I contains the localities and the field and laboratory descriptions, including descriptions of the residues, of all the units (beds) in the eight measured sections.

The five additional samples mentioned above were studied and prepared in the same manner. These were for comparison with the eight measured sections but were not collected nor described in the same detail. They are not included in this study, except in a rather general manner.

Palynological Samples. A total of 25 samples was collected for this purpose. Nineteen samples were from the stations mentioned above and the six additional were from various other lithologic units within the study area. These were submitted to L. R. Wilson for preparation and identification of the acid-resistant ultra-microscopic fossils (phytoplankton).

Mineralogical Samples. A sample from each of the 19 stations was collected for mineralogical and chemical analysis. Portions of 13 of these were submitted to W. H. Bellis for X-ray diffraction analysis of sedimented and powder slides. After an examination of the results of this mineralogical analysis of the 13 samples seven of them were selected for additional study. These were analyzed for trace elements such as boron, vanadium, etc., using an emission spectrograph. The mean grain size of the nineteen samples was not determined.

Paleontological and Paleoecological Samples. The 100 pounds of sediment from each of the 19 stations was prepared in the manner described above. The disaggregated sample was washed through a 200 mesh sieve to remove the clay, silt and fine sand fractions. The total weight of each sample was roughly calculated by weighing a quart container of the sediment and multiplying this weight by the total number of quarts of sediment processed per sample. The average weight of sediment processed per station, in grams, was 35,092.2. The total weight of each residue was also calculated for each sample by weighing a given amount of sediment before and after preparation. The average for all 19 stations is 1.861 grams of residue per 100 grams of unprepared sediment.

Residues from the 19 collecting stations were sized using standard sedimentological sieves (numbers 10, 18, 35, 60 and 120). Each sized fraction was weighed. The organic material from the +10, +18, +35 and +60 fractions was removed and sorted into taxonomic groups. The taxonomic groups were generally species but some forms (foraminifers, ostracodes and others) were sorted at the generic level and some (pseudo-zygopleurids and echinoderms) at higher levels. Each taxonomic category that occurred in the +10 fraction was weighed with the idea of using these weights as an indication of biomass. Because of the large amounts of material in the finer fractions (+18, +35 and +60) a sample splitter was employed. Each of the three size fractions from each station were split into a size that could be sorted and identified readily. In some cases this was 1/8 and in others it was 1/512 of each of the three size fractions. The total number of taxonomic groups in each split fraction was multiplied by the appropriate number to obtain an estimate of the total number of individuals of that particular group in the sized fraction. For example, the +35 size fraction from a particular sample is split so that all the organic material in 1/64 of it is identified and counted. Suppose 100 specimens (individuals) of the foraminifer, Ammodiscus are found in this split fraction. The estimated total number of Ammodiscus in the +35 size fraction of this sample is 6400 (100x64). By combining the estimated number in each taxonomic category from each size fraction of the sample it was possible to estimate the total number referable to each group in the sample. This was done for all 19 samples. The percentage that each taxonomic category (entity) contributed to the total composition of the fossil assemblage was then calculated. It is important to remember that this was not done for the +10 size fraction. All the material in the +10 fraction was sorted, identified and counted. The estimation method was applied only to the +18, +35 and +60 fractions. The +120 and pan fractions were not used in this investigation.

Size-frequency distributions were prepared for each of the larger invertebrates for each of the stations. Distributions were not prepared for the foraminifers, bryozoans, corals, ostracodes or dis-associated fossil debris such as sponge spicules, trilobite fragments and echinoderm debris. Fossils in the +10 fraction were sized more accurately (than sieving) by using millimeter graph paper, on which squares were drawn which increased by 0.5 millimeter increments. Those in the finer fractions were measured with an ocular micrometer in a binocular microscope. The total number of individuals in each taxon in each size class were recorded and a histogram prepared.

Bivalves were sized by fitting them into a square that would accommodate the entire valve. This means a diagonal across the valves was the diagonal of the square. In sizing the bivalves of the finer fractions this same diagonal was used. This provided a rough measure of the area of the shells. Maximum diameter was used to size the gastropods, coiled cephalopods and orbiculoids. The maximum diameter of the largest end was used to size orthocones and scaphopods. Most of these straight tubular fossils were broken and the size-frequency distribution may not have much significance. The same problem is encountered in using the length of these fossils. This also occurs in the sizing of other organisms but was eliminated by sizing only the unbroken individuals.

Percentage of articulation was calculated for the brachiopods, pelecypods and ostracodes. Percentage of opposite valves is reported as the percentage of brachial valves for the brachiopods and the percentage of left valves for lamellibranchs.. Percentage of opposite valves was not determined for the ostracodes. The percentage of broken (not crushed) individuals for each taxon was also calculated. This data, along with the nature of preservation, position of the organisms in the matrix, dispersion of the fossils, population density, assemblage composition and diversity provided additional information to aid in establishing the nature of the 19 fossil assemblages. This data is tabulated in Appendix III.

Statistical Techniques

Statistical analysis of the samples was made in order to aid in determining the nature of the fossil assemblages. From a visual examination of the data tabulated in Appendix III there is little doubt that all 19 assemblages reflect some, though slight, degree of mixing. This is a common situation in the geologic record (Fagerstrom, 1964, p. 1199). It was desirable to attempt to determine the nature of the particular fossil community or residual fossil community that might have been the major contributor to the mixed fossil assemblage at each of the 19 stations and to relate them to each of the 19 stations and to relate them to each other.

A Q-mode cluster analysis was employed to aid in relating these possible fossil communities or residual fossil communities. This method has been widely used in geological and paleontological studies, notably by Imbrie (1963), Imbrie (1964, p. 407-422), Kaesler (1966), Maddocks (1966), Valentine & Peddicord (1967) Mello & Buzas (1968). This is also one of the methods considered by Sokal & Sneath (1963, p. 124) for use in numerical taxonomy. Because of these ample presentations it is not necessary to go into a detailed description of the technique. It is sufficient to state that it is a method by which the degree of similarity can be quantified between two or more localities, species, specimens, etc. To use this technique the taxonomic categories that were judged, on the basis of the criteria discussed in the previous sections, to be members of a fossil community or residual fossil community were listed on one side of the data matrix. Along the other side of this matrix the 19 sampling stations were listed. Each taxon was recorded in the matrix as being either present or absent from each of the 19 stations. Figure 8 illustrates this data matrix with the presence of an entity indicated by an X and absence by a blank space.

The matrix of correlation coefficients was obtained by using the coefficient of association of Dice (1945) as given by Sokal & Sneath (1963, table 6-1). This equation is $S = \frac{2N_{JK}}{2N_{JK} + u}$ where S is the coefficient obtained, N_{JK} the number of positive matches and u the number of mismatches. Negative matches are excluded from consideration in this equation. According to Mello & Buzas (1968, p. 750):

> Maddocks (1966, p. 15) who used both Jaccard and Simple Matching Coefficients for sample by sample analysis of live ostracode populations found that the results obtained using the Simple Matching Coefficient were not interpretable ecologically,.

The Jaccard and Simple Matching Coefficients are identical except that the latter makes use of negative matches in the numerator of the equation

TAXONOMIC ENTITIES	STATIONS																		
	HORIZON I			HORIZON II				HORIZON III				HORIZON IV				HORIZON V			
	F-776.8'	G-774.7'	H-773.0'	C-796.2'	E-793.0'	F-781.7'	F-782.9'	C-803.7'	E-800.5'	F-789.9'	F-791.2'	E-826.0'	E-827.2'	G-815.1'	G-816.0'	E-835.0'	E-835.5'	G-824.0'	G-825.0'
Lingula cf. *L. carbonaria*	X		X	X					X										
Lindstroemella cf. *L. patula*								X											
Cleiothyridina orbicularis														X	X	X	X		
Crurithyris planoconvexa	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		
Mesolobus decipiens			X	X			X		X					X	X			X	X
Mesolobus euampygus	X	X			X							X	X	X	X	X	X		X
Plagioglypta sp.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X		
Anthraconeilo taffiana	X	X	X	X	X	X	X	X	X	X	X		X	X			X		
Astartella cf. *A. concentrica*											X	X	X						
Nuculopsis (P.) anodontoides	X	X	X	X	X		X	X	X	X	X	X	X			X			
Nuculopsis girtyi								X		X			X						
Nuculopsis (P.) wewokana	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		
Paleyoldia glabra								X		X									
Polidevica bellistriata	X	X	X	X	X	X	X	X	X	X	X	X	X				X		
Straparollus (A.) catilloides												X	X				X		
Bellerophon (B.) crassus												X	X						
Euphemites carbonaius	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X		
Glabrocingulum (A.) grayvillensis	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		
Ianthinopsis sp.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		
Knightites (C.) montfortianum												X	X						
Meekospira peracuta	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		
Pseudozygopleurids	X	X		X	X	X	X	X	X		X	X	X	X	X	X	X		
Soleniscus sp.															X		X		
Trepospira depressa	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X		
Pseudorthoceras sp.			X						X			X	X		X		X		
Gastrioceras sp.	X	X	X	X	X		X	X	X	X	X		X	X					

Figure 8. Data matrix of taxonomic entities and collecting stations. X, presence of entity at that station; blank space, absence of entity at that station.

(Sokal & Sneath, 1963, table 6-1). It is for this reason, and also that there is the possibility of some slight sampling bias, that an equation which excluded negative matches was chosen.

Weighting of the positive matches (the 2 in the equation) is reasonable in light of the importance of the concept of consistent and recurrent association of species in marine ecology (Jones, 1950; Thorson, 1957; Speden, 1966; and Bretsky, 1969). This is the way that this useful concept has been incorporated into the present investigation.

Cluster analysis was performed on the matrix of correlation coefficients using the weighted pair group method with simple arithmetic averages (Sokal & Sneath, 1963, p. 182-185, 189-194, 309-310). This is the method used by Kaesler (1966), Maddocks (1966) and Mello & Buzas (1968). Correlation coefficients which had exclusively high values for two or more stations were incorporated into one value. For example, if stations 2 and 5 had exclusively high values for 5 and 2 respectively then they were combined. The correlation coefficients of stations 2 and 5 for station 1 were added together and divided by two, and so on for the other 16 stations. This provided a new matrix of correlation coefficients which combined stations 2 and 5. Mello & Buzas (1968, table 4) show a simple data matrix and this method of clustering. Clustering was continued until the original 19 x 19 station matrix of correlation coefficients was reduced to a 2 x 2 matrix or until the remaining stations or groups of stations had a relationship of zero.

Since clustering represents in two dimensions what, in this study would require 18 dimensional space there is some distortion. Work by Sokal & Rohlf (1962) indicates that the clustering method used here provides the least distortion of all the methods tested by them. There are other, more sophisticated, clustering methods and perhaps one of them may have been more appropriate for this study. But as noted by Mello & Buzas (1968, p. 751):

> . . . too little is known about the degree and effect of distortion from any of the available methods as applied to these kinds of data to permit complete confidence in the selection of any one of them.

Results of the clustering were arranged in a dendrogram (fig. 10) with the highest correlation, closest similarity, as 1.0 and the lowest, or least similarity, as 0.0. This analysis permitted the consolidation of the 19 fossil assemblages into four fossil communities. The full discussion of these appears in a later section.

Data from the fossil assemblages (Appendix III) that were interpreted as fossil communities were consolidated into four tables, one for each community. This was done by averaging the total number of individuals (specimens) for each taxon from each assemblage in the community. In the case of ostracodes this average figure was divided by nine to compensate for ecdysis (Kesling, 1961, p. Q19). For disarticulated bivalves the average number of separate valves was divided by two and this result added to the average number of complete specimens. Percentages of individuals, articulation, opposite valves and broken individuals was recalculated using these new numbers. Certain forms, considered as having been transported into the fossil community, were not included in these tables. Fragmental and/or disarticulated forms (trilobites, sponges and echinoderms) were omitted from calculations made to determine the percentage each taxon contributed to the total community. These four tables are included in the discussion of the appropriate community.

A diversity index was calculated for each community using the equation given by Ziegler, et al. (1968, p. 4) and the data from each of the four tables. Taxonomic entities (species) used were those for which there is a value in column three of these tables. Each taxon is considered a single species, even though there is probably more than one species of the foraminifer and ostracode genera and of the pseudozygopleurid snails. The total number of individuals is the sum of the corresponding values of column two. This index indicates diversity only in terms of the organisms with preserved hard parts and does not consider the soft-bodied animals. The non-preserved forms constitute a considerable percentage of the total community as stated by Ziegler, et al. (1968, p. 4):

> Johnson (1964, p. 119) has summarized data which show that soft-bodied animals of modern shallow benthic communities may constitute anything from 13% to 99% of the individuals, or 33% to 93% of the species. He estimates that an average value for this data would be about 70% for both individuals and species.

The calculated diversity index is still valuable in that it gives some idea of the diversity of each community since these soft-bodied forms are absent in all communities.

GEOLOGIC SETTING

Regional Stratigraphy of the Wewoka Formation

The Wewoka Formation is part of the Des Moines Series (Marmaton Group) and is exposed in central Oklahoma (Keroher, 1966, pt. 3, p. 4195). It was named for Wewoka Creek in Seminole and Hughes Counties, Oklahoma, (Taff, 1901) and its stratigraphic position is shown in Figure 5. According to Weaver (1954, p. 59) Taff's study was primarily of the exposures in the west-central portion of Pontotoc County. This would be the Wewoka Formation as bounded by the 1900 Coalgate, Oklahoma Quadrangle. The Geologic Map of Oklahoma (Miser, et al., 1954) shows the Wewoka extending northeastward from the east-central part of Pontotoc County through Hughes, Okfuskee, Okmulgee and Tulsa Counties to the Arkansas River.

The following information concerning the Wewoka Formation in Hughes County was obtained from Weaver (1954, p. 58-66). The formation is composed of four massive to thin-bedded sandstone units separated by thick interbedded and intertonguing shales. It outcrops in a broad belt approximately 7 miles wide that trends north-eastward across the west-central and north-central part of the county (fig. 6). Strike is approximately N. 25° E. and the regional dip is about one degree to the northwest. The Wewoka is overlain conformably by the Holdenville Shale and lies conformably on the Wetumka Shale. Generally the sandstones are fine grained, friable and light brown to reddish brown and orange in color. There are some conglomeratic beds near the base of some of the sandstone units. The shales are bluish gray to yellowish gray-brown, sandy, silty and, in places, quite fossiliferous. Total thickness of the Wewoka in Hughes County is approximately 680 feet. Of this 680 feet 270 feet is sandstone and 210 feet is shale. Northward this thickness remains fairly consistent (650 feet in Okmulgee County, Oakes, 1963, p. 42 and 780 feet in Okfuskee County, Reis, 1954, p. 35). However, there is a significant change; the shale units thicken at the expense of the sandstones. Sandstone units become thinner and more numerous. Weaver (1954) mapped four main sandstones with three intervening shales in Hughes County while Oakes (1963) mapped 26 main sandstones with 25 intervening shales in Okmulgee County. Further north, across the Arkansas River, Wewoka equivalents are limestones and shales (Oakes, 1951). Southward the Wewoka thins to a feather-edge in Pontotoc County where it is overlapped by the Holdenville Formation (Morgan, 1924, p. 93).

Topographic Nature of the Study Area

The location of the study area within Hughes County has been given in a preceding section (fig. 7). Plate I is the topographic map of this area which is a portion of the west half of the NW$\frac{1}{4}$ of Sec. 33, T. 7 N., R. 9 E. This map also indicates the location of the measured sections, location of reference points for elevations and bearings and the geographic locations of the 19 collecting stations.

The stratigraphic portion of the Wewoka under study is the exposed shale/claystone between sandstones designated as Pwk-3a and Pwk-2 by Weaver (1954). Maximum thickness of this interval in the area is 128.3 feet (Section E). Of this, 78.6 feet is exposed and the remaining 49.7 feet is covered. Topographic mapping was controlled by the available exposures of this stratigraphic interval. As a result the map is basically one of the drainage of the area.

There is one permanent stream (water was present at all times during the field work) which drains the overflow from Lake Holdenville. This lake is located immediately southeast of the study area. The dam at the east edge of the mapped area is the main one of several such dams (W.P.A.) which were apparently built to maintain a higher water level in Lake Holdenville and check erosion. Eight gullies, or ephemeral streams, drain into the permanent one. It was along six of these that measured sections were obtained. The other two sections (A and H) were measured along the banks of the major drainage. In all cases, except one (Section G), the base of the measured sections started in or near the bed of the permanent stream. Three of the measured sections (E, F, and G) more or less terminate in open glades within a wooded area. The open side of the glades is to the south or southwest with the remaining sides being steep exposures of claystone. The tops of Sections E and G are at isolated sandstone (Pwk-3a) exposures on a heavily wooded ridge. These sandstone exposures are separated from the underlying shale/claystone interval by covered intervals of 15 to 28 feet. The contact of this interval with the underlying sandstone (Pwk-2) was also covered. Therefore it was impossible to relate the sections to each other by using the base of the shale/claystone interval or the sandstone (Pwk-3a) as a datum.

Stratigraphic and Depositional Nature of the Study Area

General Statement

Lithologically, exposures of the Wewoka in this area are rather homogeneous. Basically the lithology is a shale and claystone with numerous irregular, laterally non-persistent calcareous and ironstone nodule horizons. These nodular horizons are never more than 0.2 feet thick and "migrate" up and down in the section as well as disappear and reappear laterally. Shale composes the lowest part of the interval and the overlying claystone can be divided into three units on the bases of subtle differences in lithologic and paleontologic properties.

Elimination of the nodular horizons from this interval leaves approximately 95 to 98% of it to be divided between shale and claystone. Shale is used in this paper to denote the presence of fissility and claystone the lack of this property (Pettijohn, 1957, p. 341). The presence or absence of fissility is the basic difference between shale and claystone and can be readily observed in the field and laboratory. Section E is the thickest section measured (128.3 feet). Thirteen feet of this 128.3 feet is exposed and inferred (covered) sandstone, which leaves 115.3 feet of shale/claystone. Weaver (1954, p. 64) records a thickness of 120.0 feet for this interval. Of this 115.3 feet, 10% (± 12 feet) is shale and 90% (± 104 feet) claystone. On this basis the dominant lithology is claystone. Although the contact with the underlying sandstone was never observed, and much effort was exerted to find such an exposure, it is assumed in this study that the shale is the lithology immediately overlying the sandstone.

In all cases the contacts between the claystone and underlying shale are gradational. Where exposures are naturally good or can be obtained by digging, the two lithologies interfinger and it is difficult to determine where one stops and the other begins. This gradational nature is also indicated by the contained biotic elements. Proceeding upward from the base of the shale there are more and better preserved fossils which dominate the overlying claystone.

Careful study in the field and laboratory revealed some subtle differences within the claystone portion of this interval. These differences are in the color of the claystone and the contained fossils, both of which change gradually upward in the section. Using these subtle, gradual changes the remaining interval can be divided into three separate claystone units which reflect different environments of deposition.

Shale

Lithology and Paleontology. This shale is dark gray to black in color, hard, platy to fissile and pyritic. There may or may not be "phosphatic" nodules scattered randomly or concentrated in layers. One or more calcareous nodule horizons occur in the shale. Dimensions of these nodules range from 0.65 feet to 0.8 feet in length, 0.4 to 0.5 feet in width and are 0.2 feet thick. They can best be described as flattened ovoids of argillaceous carbonate mudstone which are dark gray to black in color. Usually they are conspicuous because of their resistance to weathering but they are also easily covered by slumped shale and claystone.

There is only one nodular horizon which has any lateral extent and it occurs in this shale unit. Locality A' was included because it is an excellent exposure of this particular (calcareous) nodular horizon and the underlying and overlying fossiliferous shales. At sections A and B (bed 2) it is at or near water level. Halfway between the base of sections B and C it disappears, probably due to a combination of the slight dip and alluvium. Attempts to expose it by digging at the base of section C were unsuccessful. There is a possibility that it does not occur at the base of section C due to a lateral change in facies. This conclusion is supported by the sporadic occurrence of similar nodular zones higher in the interval. Abundant marine invertebrates are contained in this nodular horizon. This is not true of any of the other nodular beds. It is an argillaceous carbonate mudstone and the shales above and below (approximately 0.5 to 1.0 feet in both directions) are highly fossiliferous.

This entire shale interval contains abundant plant debris, conularids, orbiculoids, some foraminifers such as Bathysiphon and Ammodiscus, pyrite filled burrows?, scolecodonts, condonts, a few ostracodes, fish debris, rare goniatites and faecal pellets. Most of these fossils are partially or completely replaced by pyrite. Other biotic elements include epi- and infaunal molluscans, spiriferid and rhynchonellid brachiopods, bryozoans and horn corals. Because the latter elements are represented by internal molds and badly broken specimens and because they do not occur consistently throughout the lithology it is suggested that they may have been transported from another environment. However, these observations could be explained without calling on transportation. This is probably a mixed fossil assemblage, but because none of the criteria discussed earlier have been applied the nature of the assemblage can only be suggested.

Depositional Environment. This unit is interpreted as intertidal to shallow subtidal, that is a tidal flat to marshy area along the margin of a shallow epicontinental sea. The fossiliferous nodular horizon within the unit probably reflects a momentary return of subtidal marine conditions in the area. This entire unit would correspond, more or less, to the Lingula phase (3r and 3p) of Elias (1937, table 1); the Lingula phase of Duff, et al. (1967, p. 234) and the Planolites and Lingula association of Boger (1964, p. 149). Analogy to these concepts is only meant to aid in placing this unit with regard to the probable position of the strand line and is not meant to imply water depths assigned by any of the above authors.

Lithologic characteristics of this unit indicate that environmental conditions were generally toxic and the sediments rich in fine organic material which has not oxidized. Palynological residues prepared by L. R. Wilson (personal communication, 1969) contain an abundance of plant material and other organic detritus. McCrone (1963, p. 55) in discussing the black shale of the Bennett Shale Member states:

> Conditions at, or soon after, the deposition of the organically rich mud must have been such that the organic material (plant and animal) was only partially decomposed because of insufficient oxygen. Therefore, it seems likely that this decomposition was effected principally by aerobic bacteria, but anerobic bacteria, and enzymatic reactions (which can continue even after the death of enzyme-producing organisms), also might have been involved. Sulfides of hydrogen produced during this decay must have added to the toxicity of the environment and contributed, during diagenesis, to the traces of pyrite now present in the shale.

Such conditions are possible in a marshy or backswamp area associated with deltaic development and also in some tidal flat areas. These areas could occur where a coal swamp extends to the waters edge or where such a swamp becomes inundated during a transgression. The former situation suggests the mangrove swamps along the Florida coasts today. While there is no evidence for postulating a coal swamp the black shale does contain abundant well preserved plant stems some of which are completely replaced by pyrite. The palynological sample from this unit, contained the most abundant and diverse flora of all the samples processed. L. R. Wilson (personal communication, 1969) indicated that the deposit was very close to an area that was covered by upland vegetation.

Other biological data are compatible with the environmental interpretation. Nekto-planktonic forms such as conularids, goniatites, fish (sharks) and possibly conodont-bearing organisms could have been washed into the area after death, may have ventured into the area and died because of unfavorable conditions or were stranded on the flats as the tide receded. Orbiculoids are commonly associated with black fissile shales and Recent inarticulates are found from the tidal zone down to a depth of 100 fathoms (Schuchert, 1911). Arenaceous foraminifers and ostracodes could have lived in, been carried into or died in this environment. Both of these microfossil groups are reported from deltaic marshy areas of the present-day Gulf Coast (Lankford, 1959; Curtis, 1960 and Phleger, 1960). Providing the scolecodonts can be used to infer the presence of polychaete worms or their ancestors, they can be considered as infaunal elements in this environment. While at Woods Hole the author observed rather large marshy tidal flat areas which contained numerous infaunal polychaetes. Faecal pellets are to be expected in any area where there is animal life. The remains of other organisms, because of their scarcity and nature of preservation are interpreted as having been transported into the environment.

Mineralogically most of the well preserved fossils, orbiculoids, conodonts, scolecodonts and vertebrate (fish) debris, contain a considerable amount of phosphate. The preservation of such remains is explained as follows by McCrone (1963, p. 55):

> These mainly phosphatic remains were probably preserved because of, rather than in spite of, the toxic conditions, much in the same way that formaldehyde preserves flesh from decay by arresting bacterial activity.

This writer does not mean to imply that only phosphatic skeletal material can be preserved under these toxic conditions but rather that the excellent preservation of these forms may support the view that they were not transported far after death. Arenaceous foraminifers, which are abundant in some portions of this unit, are also excellently preserved.

This unit is similar in a general way to that described by Weller (1957, p. 351) for the lower part of the middle shale (member 8) of the "idealized" Pennsylvanian cyclothem of western Illinois.

Lower Claystone

Lithology and Paleontology. The first of these claystone units has a gradational contact with the underlying shale which has been described above. This unit is a yellowish brown, platy to blocky slightly calcareous claystone with ironstone (sideritic) nodules. It makes up about 45% ($\pm$ 47 feet) of the total claystone interval. The ironstone nodules are yellowish brown to orange, soft and much smaller than the carbonate mudstone nodules of the underlying shale. They occur scattered throughout this unit and also as discontinuous horizons.

Mollusks dominate this unit both in abundance and diversity. The four major classes are well represented. Infaunal pelecypods

(Polidevica, Paleyoldia and Nuculopsis) gastropods (Glabrocingulum (A.) grayvillensis and Trepospira depressa), straight and coiled nautiloids, goniatites and scaphopods are the main constituents in this fossil assemblage. There are also brachiopod and echinoderm (ophiuroid, asteroid, echinoid, crinoid and holothurian) fragments. The microfossil assemblages are dominated by arenaceous foraminifers, both in abundance and diversity. There are a few ostracodes, conodonts and scolecodonts and numerous faecal pellets. Faecal pellets of the size and shape described by Moore (1931a; 1931b) from nuculoid lamellibranchs are the dominant types. This fossil assemblage is interpreted as indigenous. Support for this interpretation is found primarily in the nature of the preservation and the relationship of some of the organisms to the enclosing sediment. Preservation of all of these forms is excellent, details of surface ornamentation are nearly as clear as that of shells collected on a present-day beach. The only fossils that are consistently broken or disassociated are the scaphopods, straight nautiloids and echinoderms. Some of the nuculoids were observed in what could be considered life position (Stanley, 1968, fig. 3). Figure 20 of Plate IV is Polidevica in what is considered life position. Most of the bivalves (pelecypods, brachiopods and ostracodes) are articulated. There appear to be few elements that may have been transported into this environment, particularly when compared to the assemblages from the underlying shale.

Depositional Environment. Depositionally this unit is interpreted to have been shallow subtidal, possibly the margins of a slightly restricted bay or delta front area. This would relate to the molluscan phase (4r and 4p) of Elias (1937, table 1); phases 4 through 6 of Duff, et al. (1967, p. 234) and associations 3 through 5 of Boger (1964, p. 149-151).

Biologically this unit fits fairly well with the euphemitid and nuculanid "communities" of Stevens (1966, p. 1128) and the Eupemites fauna, Stevens (1965, p. 76). Some of the characteristics of these two, nuculanid and euphemitid, assemblages, as given by Stevens (1966, Table 2), are listed in Table 1. These depths (table 1) are reasonable for

Table 1

Inferred Environmental Requirements of the Nuculanid and Euphemitid Assemblages (modified from Stevens, 1966)

Fauna	Salinity	Energy	Turbidity	Depth (meters)
Nuculanid	< 35	low-high	moderate-high	1-5
Euphemitid	> 35	low-high	moderate-high	0-4

the environment suggested for this lower claystone. The present author has no evidence regarding turbidity and energy that would contradict that given by Stevens. There is no evidence, such as associated evaporites, that would suggest anything about the salinity of this Wewoka unit. Lack of any associated evaporites permits the suggestion that the salinities may have been more or less normal. However, if the environmental placement is correct, influx of fresh-water (runoff) could have reduced the salinity.

Lithologically and biologically this claystone is possibly analogous to the molluscan assemblages of the upper part of member 8 of the "idealized" Pennsylvanian cyclothem of western Illinois as described by Weller (1957, p. 352):

> The upper gray part of member 8 has yielded some of the largest and best-preserved assemblages of invertebrates found in Illinois. These are generally mixed molluscan-brachiopod faunas including such pelecypods as Nuculana and Leda, bellerophontid gastropods and Phanerotrema grayvillensis, productid and chonetid brachiopods and Composita, lophophyllitid corals, orthocerids and many other restricted forms. Most of the molluscan species are best represented in shale that is only slightly calcareous, and as this material increases dominance passes to the brachiopods and bryozoans. . . .

The gradual change noted by Weller between the fossil assemblages in the upper part of member 8 are also observed between the lower and middle claystones of the Wewoka in the study area. The middle claystone is more calcareous and contains an assemblage of brachiopods, corals and bryozoans.

Sediments which occur in Recent bays and delta front areas are lithologically and biologically similar to this claystone. Stevens (1966, p. 1128) suggests that his nuculanid and euphemitid assemblages lived in very shallow pools, isolated bays or inlets.

The enclosed bay assemblage of Parker (1960, pl. 1)contains molluscans which are morphologically similar and in some cases, taxonomically related to the assemblage in this claystone. Enis, Mulinia, Tagelus and Retusa appear to be morphologically similar to Paleyoldia, Schizodus, Allorisma and Girtyspira, respectively of the Wewoka. The Recent pelecypod Nuculana is morphologically similar and taxonomically related to Polidevica from this claystone assemblage.

The Recent assemblage also contains the ophiuroid Amphiodia and there is fossil evidence of ophiuroids in the abundance of preserved ossicles. These are also the same Recent forms which Parker (1959, pt.

II of pl. I) indicates are characteristic of enclosed bays of variable low to intermediate salinities along the central Texas coast.

Forms indicated by Parker (1956, pls. I-III) as delta front and lower to upper sound appear to have morphologically similar forms in the ancient assemblage. These are, with the fossil forms in parentheses after the Recent forms: Nuculana (Polidevica); Mulinia (Schizodus); Tagelus (Allorisma); Littoridina (Meekospira); Cerithidea, Terebra and Cerithium (pseudozygopleurids); Retusa (Girtyspira); Polinices (Trepospira); Nassarius (Glabrocingulum) and Thais (Worthenia). There are also ophiuroids, echinoids and polychaetes in these Recent environments and analogous material in the fossil assemblages.

Studies of the foraminifers (Phleger, 1960) and ostracodes (Curtis, 1960) in the Mississippi Delta region record arenaceous and other foraminifers and cytherid ostracodes from bays and delta front areas. The microfossil assemblage in this lower claystone is thus compatible with the environmental interpretation presented.

None of these Recent forms are restricted to these specific environments and these analogies are not meant to imply that the fossil organisms only lived in these same types of environments during the deposition of this lower claystone. The author only wishes to point out that the analogies exist and that in light of the deltaic nature of the Wewoka sandstone units (Weaver, 1954) such environments are plausible.

Middle Claystone

Lithology and Paleontology. Overlying this lowest claystone, with the same type of gradational contact as between the shale and claystone, is the next (middle) claystone unit. While it is still a platy to blocky claystone, the color is more of an olive gray to faint bluish gray. This middle claystone composes about 20% (± 21 feet) of the total claystone. The ironstone nodules and nodular horizons still occur but are less abundant than in the underlying unit. Claystone of this unit is calcareous and contains small (peanut-sized) irregular calcareous nodules.

Brachiopods (spiriferids and chonetids), horn corals, bryozoans, trilobites, crinoid debris and fusulinids are the primary biotic elements in this claystone. There are some of the molluscans of the types contained in the underlying unit, particularly pseudozygopleurid snails. Just as there is no sharp contact between this claystone and the underlying one so there is no point where a line can be drawn to divide the fossil assemblages of the two lithologies. There is a gradual change from one type of assemblage to the other. Few, if any, of the lower forms disappear but their total numbers decrease. There is the gradual appearance of the characteristic organisms of this second claystone unit. In terms of numbers, they are the dominant fossils. The microfossil assemblage does not change greatly. Foraminifers and ostracodes become about equal in number, conodonts remain rare and scolecodonts decrease and are conspicuous by their absence. As mentioned, fusulinids, the only new microfossil element, occur in the claystone. Faecal pellets are present, in more or less the same abundance as below. The dominant biotic elements listed above are considered to be indigenous. Excellent preservation, high articulation percentages and low percentages of broken individuals tend to support this tentative interpretation.

Depositional Environment. This unit is interpreted as having been deposited subtidally and farther from shore than any of the units studied. It may represent a prodelta area or the central portion of a more open bay. According to Elias (1937, table 1) it would be analogous to his mixed and brachiopodal phases (5r, 6r, 5p and 6p). The brachiopod association of Boger (1964, p. 151-152) is probably analogous to the lower part of this unit. In terms of the assemblages reported by Stevens (1966, table 2) the assemblage in this unit would be more or less analogous to his chonetid and dictyoclostid-Composita assemblages. Here again the present author would agree that a water depth of less than 10 meters for this assemblage is realistic.

The energy and turbidity of this Wewoka environment are probably very similar to that reported by Stevens (1966, table 2) for the environment of his chonetid assemblage, namely low to moderate and high respectively. If this environmental interpretation is correct it is to be expected that the salinities would be less affected by dilution from runoff since it (the environment) is located farther offshore. Regarding the environment of his chonetid assemblage, Stevens (1966, p. 1124) states:

> . . . may have lived in rather turbid bays where the bottom was protected from violent current or wave action . . .

This unit is possibly analogous to member 9 of the "idealized" Pennsylvanian cyclothem of western Illinois (Weller, 1957, p. 352). In this area, this claystone is the culmination of marine conditions.

There are no forms that are living today with which we can compare the dominant forms of this fossil assemblage to strengthen the suggested environmental interpretation.

Upper Claystone

Lithology and Paleontology. The remaining 35% (± 36 feet) of the total claystone interval is the uppermost claystone unit. It maintains the same gradational contact with its underlying neighbor as do the other units within this interval. The color is yellowish to orangish brown and brownish yellow, which is similar to that of the lowest claystone unit. It is platy to blocky and contains numerous ironstone (sideritic) nodules and nodular horizons. This claystone contains some silt and very fine to fine sand size quartz grains which appear to become more abundant up section. Within the area studied in detail the top of this unit is invariably covered but at Locality J the nature of its contact with the overlying sandstone is exposed. This contact is gradational. There are very thin (less than 0.1 feet) beds of sandstone interbedded with this silty, sandy claystone for approximately 2 to 3 feet. Upward the sandstone beds become thicker while the claystone intervals thin until the base of a massive bed of sandstone is encountered.

The fossil assemblage of this uppermost claystone is dominated by microfossils. The arenaceous foraminifer, Bathysiphon, is the most abundant organism. Smooth shelled ostracodes are also present as is plant debris in the form of carbonaceous fragments. In the lower portion of this lithologic unit some specimens of Lingula and the articulate brachiopod Mesolobus are found along with some crinoid columnals. This lower fossil assemblage probably represents a transition between the assemblage of the underlying claystone and the microfossil assemblage of this unit. Larger (marco) invertebrates decrease in numbers upward so that there is a gradual change. The lithologic change from the underlying unit is also gradational.

Depositional Environment. This unit appears to reflect a return to nearshore conditions. It may be thought of as being analogous to the green shale phase of Elias (1957, table 1). This analogy holds only with regard to the relationship to the other phases defined by Elias and shoreline. There is no comparison in terms of color, biologic content, or suggested water depth. The basal parts of the upper claystone may represent Elias's Lingula phase. There are some biological characteristics of this unit which are similar to the Jonesina association of Boger (1964, p. 148).

Presence of carbonaceous material, possibly plant debris, suggests a nearness to shore. The absence of marine organisms, except foraminifers and some ostracodes, indicates that the physical and chemical conditions were not favorable for their survival.

Occurrence of chonetids in the basal portion suggests that they were able to tolerate less favorable conditions than other marine organisms. They may have lived nearer the shoreline than the other organisms of the underlying marine unit. Elias (1962, p. 110) states:

> Chonetids generally tend to be gregarious and when occurring in great number and not mixed with other invertebrates, they seem to indicate waters shallower than normal for the majority of articulate brahiopods.

Arenaceous foraminifers and some ostracodes are found in brackish water areas associated with deltaic sedimentation, particularly in marshy areas (Lankford, 1959; Curtis, 1960 and Phleger, 1960). It is suggested that this unit represents a marshy area or a restricted bay in a deltaic area which received a great deal of freshwater runoff and terrigeneous clastics. Member 10 of the "idealized" Pennsylvanian cyclothem of western Illimois is possibly analogous to this upper claystone.

Sandstone

Lithology and Paleontology. The highest unit in this area is the sandstone Pwk-3a. It was not studied in detail in the laboratory. The following remarks are based on field examination and microscopic study of hand specimens in the laboratory. It is moderately soft, friable, thick (massive) to medium and thin bedded, ferrugineous, very fine to fine sand size quartz sandstone. The quartz grains are subangular to subrounded and appear to be fairly well sorted. There is evidence of large and small scale cross bedding. Color varies from reddish brown to orangish brown and brownish yellow. What cement is present appears to be some form of iron oxide. Some identifiable trace fossils and fragments of plants were observed. Pieces of *Stigmaria*, *Lepidodendron* and *Calamites* were collected from sandstone float.

Depositional Environment. Since this investigation did not deal directly with the nature of the sandstone any interpretation of the depositional environment must depend primarily on the literature.

Weaver (1954, p. 96) makes the following statement concerning the paleogeography of Desmoinesian units:

> The irregular lensing of the sandstones across Hughes County, their contained floras and faunas, and the intertonguing of the sandstones with shales in many places are a few of the characteristics which indicate that the beds were deposited near the shoreline as it gradually shifted to the north and west. . . . The sandstone tongues described in the section on the Calvin sandstone and other formations indicates a deltaic type of environment.

This interpretation is compatible with observations made by the present author. For example, cross bedding is a common characteristic of sands within a deltaic complex as is the presences of conglomeratic material

(Shepard, 1960 and Fisk, 1961). It is because of the deltaic nature proposed by various authors for these Wewoka sandstones and because observations made by the present author on the shale/claystone sequence do not contradict them that the specific environments (associated with deltas) have been suggested for the shale/claystone units.

Relationships between the eight measured sections in terms of the lithologies and depositional environments are shown in Plate II. The lack of laterally persistent lithologic units and the gradational nature of the contacts prevented preparation of a lithostratigraphic cross-section. It was essential to relate the sections in some manner in order to select the 19 collecting stations. Therefore the section was constructed using an elevation of 770.0 feet above sea level as the datum. Each of the lithologies and depositional environments described above are represented by a different pattern on this cross-section. Stratigraphic positions of the 19 collecting stations are also indicated on the section.

With this topographic, stratigraphic and environmental framework it is possible to proceed to the next phase of the study, that of analyzing the fossil assemblages from the 19 collecting sites.

Cyclicity

Before discussing the nature of the 19 fossil assemblages the author would like to consider briefly the possibility of cyclicity in the Wewoka Formation. There is evidence of a transgressive-regressive cycle within the shale/claystone interval studies.

A brief, not at all detailed, examination of two other shale/claystone intervals within the Wewoka Formation suggest cyclicity.

There is a repetition of the fossil assemblages and color changes observed in the area studied in detail.

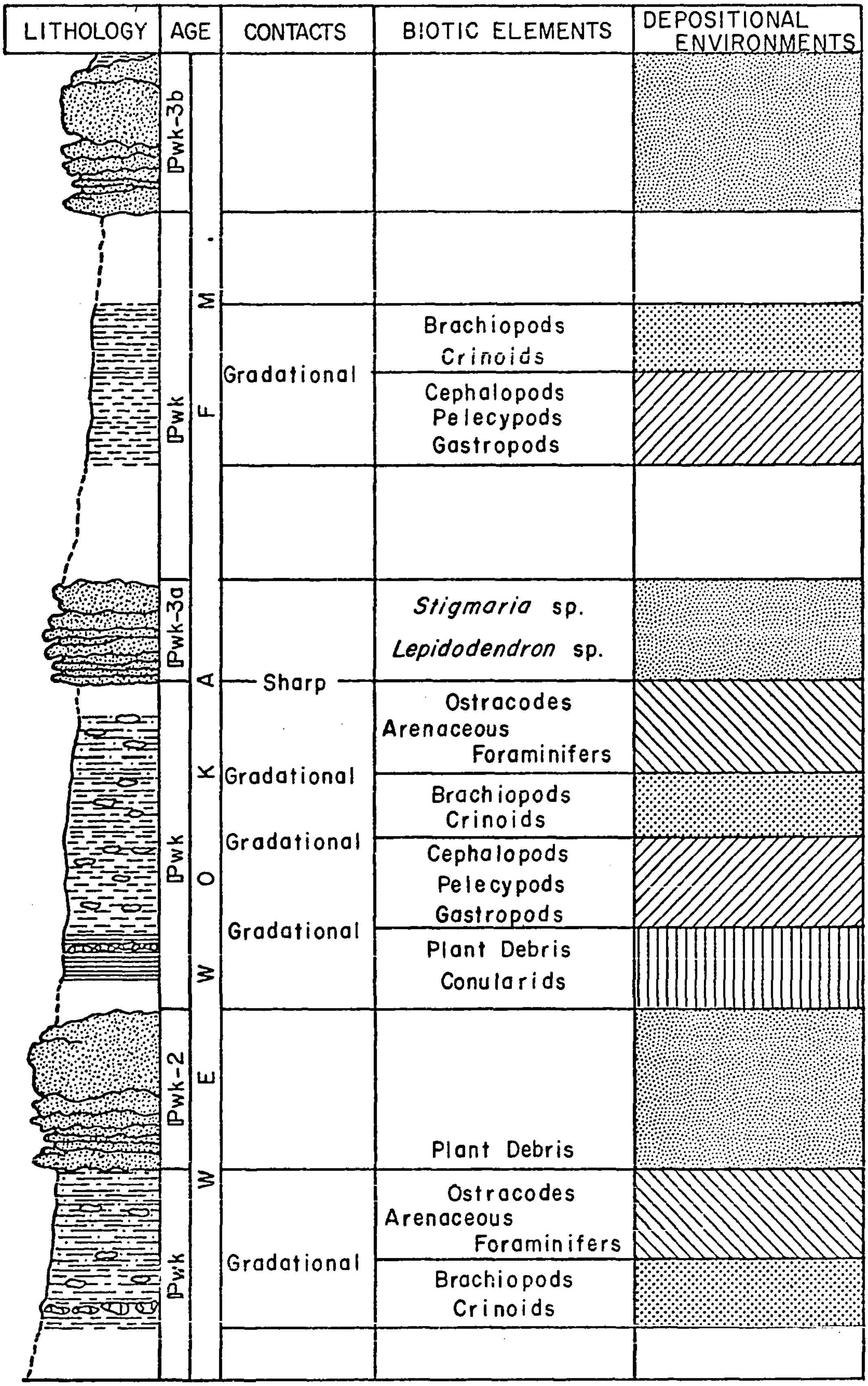
At Girty's locality 2006 there is approximately 54 feet of claystone exposed, the base and top being covered. Ten feet of sandstone (Pwk-3b) is exposed at the very top of the hillside, but is separated from the underlying claystone by a covered interval of approximately 28 feet. The lower 9 feet of this 54 feet is similar biologically and in color to the lower claystone in the study area. Molluscans dominate the fossil assemblage. Many of the same forms that occur in the lower claystone (Glabrocingulum, Trepospira, Polidevica, Paleyoldia, and Nuculopsis) are found here. The upper 45 feet of this exposure (Girty's 2006) is similar paleontologically and in color to the middle claystone of the area studied. Brachiopods (Cleiothyridina, Mesolobus and Chonetinella), lophophyllitid corals, bryozoans and crinoids are the dominant biotic elements in this upper 45 feet.

A similar examination was made of the exposure at Girty's locality 2010. There is approximately 80 to 90 feet of claystone exposed and 20 to 25 feet of the overlying sandstone (Pwk-2). The basal 30 feet of this claystone contains a fossil assemblage dominated by brachiopods, crinoids, corals and bryozoans and the color is a dark olive gray to bluish gray. Similarity of this 30 feet to the middle claystone (northwest of Lake Holdenville) is striking. The remaining 50 to 60 feet is orangish brown to yellow brown in color and contains abundant ironstone nodules. Examination of washed residues from this interval revealed a great abundance of fine to very fine sand size quartz grains, of the arenaceous foraminifer Ammodiscus and some smooth shelled ostracodes.

Again there is a striking resemblance between this unit and the upper claystone in the study area.

The similarity between these three stratigraphically different, but closely related, claystone intervals suggests that there is a cyclicity in the deposition of the Wewoka Formation in Hughes County, Oklahoma. Figure 9 is a graphic representation of the cyclicity inferred from the observations of these claystones. Much more detailed work would be necessary to firmly establish this repetition. The present study of only a small portion of the total Wewoka provides a basis for a much broader study of cyclicity in Des Moines sediments of Oklahoma. Based on what is known about cyclic sedimentation in other Upper Carboniferous (Pennsylvanian) sequences both in North America and Europe, Wewoka cycles are to be expected.

Figure 9. Cyclicity of depositional environments in a portion of the Wewoka Formation in west-central Hughes County, Oklahoma. For explanation of lithologic and environmental symbols see Plate II.


LITHOLOGY
AGE
CONTACTS
BIOTIC ELEMENTS
DEPOSITIONAL ENVIRONMENTS
IPwk-3b
IPwk
IPwk-3a
IPwk
IPwk-2
IPwk
WEWOKA FM.
Gradational
Brachiopods
Crinoids
Cephalopods
Pelecypods
Gastropods
Stigmaria sp.
Lepidodendron sp.
Sharp
Ostracodes
Arenaceous Foraminifers
Gradational
Brachiopods
Crinoids
Gradational
Cephalopods
Pelecypods
Gastropods
Gradational
Plant Debris
Conularids
Plant Debris
Ostracodes
Arenaceous Foraminifers
Gradational
Brachiopods
Crinoids

BENTHIC MARINE COMMUNITIES OF THE WEWOKA FORMATION

General Statement

Information from the fossil assemblages at the 19 collecting stations was compiled and pertinent taxa selected for the data matrix. Q-mode cluster analysis was performed on this data matrix and the degree of similarity between the 19 stations determined. The dendrogram (fig. 10) is a graphic representation of this similarity. A value of 1.0 for the correlation coefficient indicates the closest possible similarity and 0.0 the least possible. These correlation coefficients were calculated using the equation of Dice (1945) to take into consideration the concept of consistent and recurrent association between species.

Selection of the taxonomic entities used in the data matrix was based on an evaluation of the data for each entity. These data are presented in tabular form in Appendix III for each of the 19 fossil assemblages. Criteria used in this evaluation were discussed in an earlier section of this paper.

If a size-frequency distribution was available the form was included in the data matrix. However, the nature of preservation, position with respect to enclosing lithology, dispersion of fossils, population density, composition and diversity of the assemblages and percentages of articulation, opposite valves and broken individuals were also used to aid in the selection. It was judged, from these criteria, that the taxa

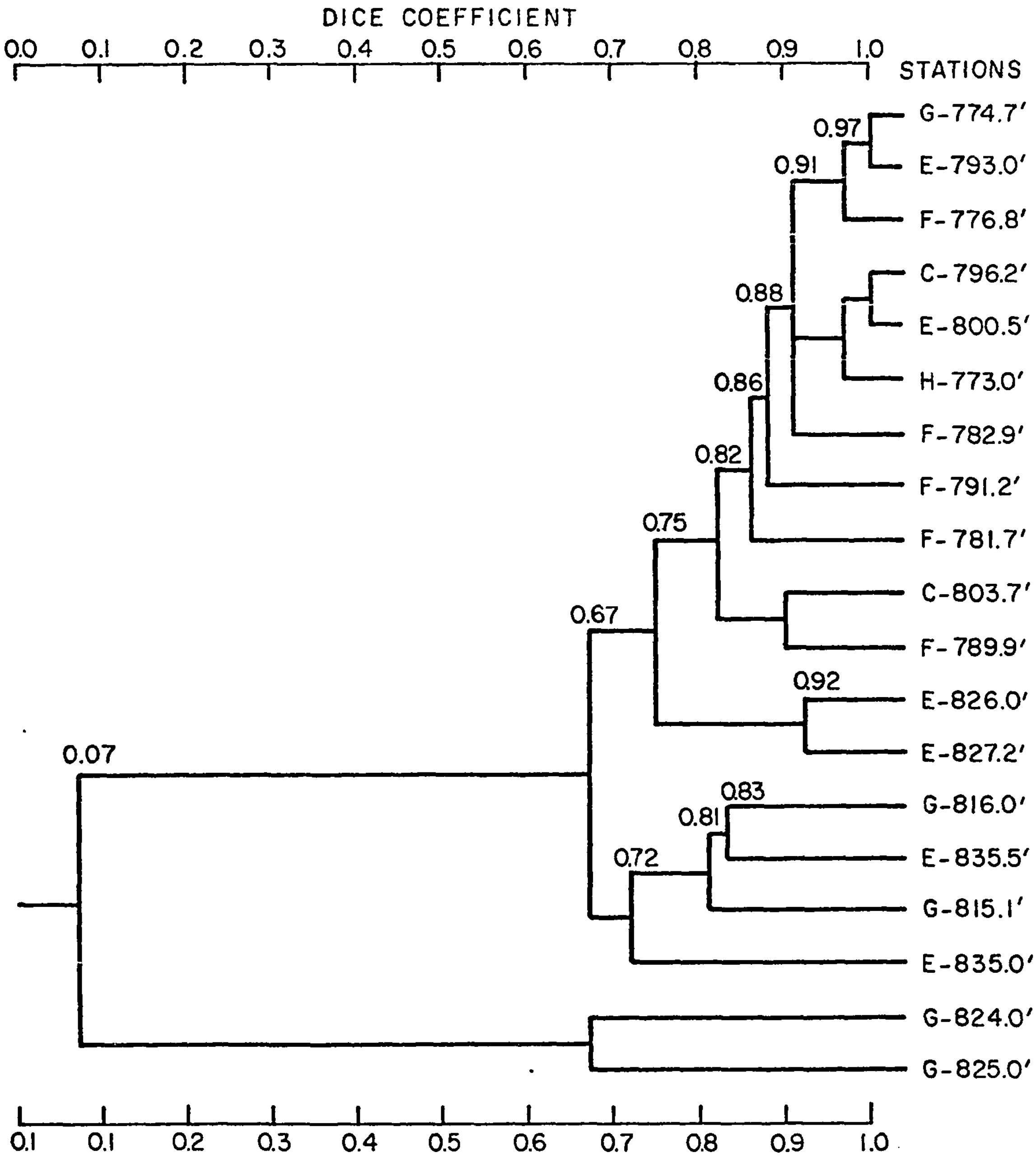


Figure 10. Dendrogram indicating the degree of similarity between the fossil assemblages at the nineteen collecting stations.

selected were members of a fossil community and the basic contributors to the fossil assemblages from each of the 19 stations. There is some slight mixing in these 19 fossil assemblages, that is there are some fossils present in each assemblage which are not considered as members of the communities as defined in this study. These "foreign" elements are interpreted as members of other, laterally associated, communities. These basic contributors then represent the fossil communities that existed at the time of deposition and can be referred to as residual fossil communities.

It is necessary at this point to look more closely at the terms fossil community and residual fossil community as used by Fagerstrom (1964, p. 1199). He defines these terms as follows:

> A fossil community is a fossil assemblage in which nearly all the specimens belong to the same ecological community and are present in about the same sizes and numbers as when they were alive. Fossil communities have undergone a minimum of preburial alteration; most of the fossils are found in essentially their original habitats and living positions.
>
> A residual (or winnowed) fossil community is a fossil assemblage in which nearly all the specimens belong to the same ecological community but are not present in the same numbers and sizes as when they were alive. A residual fossil community has undergone moderate alteration by preburial factors, the net effect of which has been to remove selectively only part of the original community.

To this writer the basic difference appears to be the amount of preburial alteration that is recognizable from the size-frequency distributions of the community members. Such alteration can be due to physical, chemical and/or biological factors with no reliable method for separating the causes. All of the 250 size-frequency distributions prepared for the organisms in the Wewoka fossil assemblages show some alteration but its exact cause cannot be determined. It would seem that such alteration, whether minimum or moderate, is to be expected in any and all populations of fossil organisms and probably most, if not all, populations of living marine invertebrates (fig. 2). This statement is not meant to be factual but only a plausible suggestion.

This writer does not feel that it is possible to differentiate between minimum and moderate alteration of the size-frequency distributions and presents the following definition of residual fossil community. Residual fossil community refers to a community composed of populations of organisms which are interpreted as having lived, died and been preserved at or near the collecting site. Alterations of the size-frequency distributions of these organisms will vary from slight to severe due to the effects of various physical, chemical and/or biological factors. Often these distributions are not in themselves sufficient to establish the nature of the population but used with other independent criteria (as discussed previously) their usefulness is strengthened. This definition is the one used in the remainder of this paper.

Basically the term "community" is a convenient abstraction but in this study it is partly subjective and partly statistical based on the experience of the investigator and the statistical techniques employed. It is considered to have both lateral and vertical extent and is, therefore, a three dimensional abstraction. Also it should be remembered that the communities defined in this study are based on samples of fossil populations. It is on the abundance and nature of the fossils contained in these samples that the communities are constructed.

A total of 250 size-frequency distributions were prepared from the 19 assemblages. All of these appear to be positively skewed. No statistical tests were conducted to check the degree of positive skewness. There are both parametric and non-parametric tests for doing this, but time did not permit their use. Visual inspection was the sole means of determining the nature of these distributions. Representative size-frequency distributions, from the total 250, are presented as Figures 11 through 21. These distributions are grouped and illustrated as parts of the four residual fossil communities defined by the Q-mode cluster analysis. The majority of these distributions (figs. 11-B, 12-C, 12-E, 15-A, 16-A, 16-D, 17-C, 20-D and 21-F are a few of the obvious ones) show the effects of solution, selective predation, low mortality, recruitment failure and/or transportation of certain size classes of individuals. However, in terms of all the criteria used, these forms are considered as representing fossil communities that lived, died and were preserved at or very near the present collecting site.

Consolidation of the 19 assemblages into the four groups termed residual fossil communities can be seen in Figure 10. These four residual fossil communities are basically of benthic marine invertebrates, but also include nekto-planktonic forms (cephalopods, conularids and fish). All the assemblages from the lower three horizons (I, II and III) are correlated to one another at a value greater than 0.8. This includes 11 of the 19 total assemblages and is referred to as the <u>Glabrocingulum</u> Community. Two assemblages from horizon IV (E-826.0' and E-827.2') are correlated at the 0.92 level, and are combined into a Transitional Community. Of the remaining six assemblages, four can be related above the 0.7 level. Two of these are from horizon IV (G-815.1' and G-816.0') and two from horizon V (E-835.0' and E-835.5'). These four are referred to as the Cleiothyridina Community. The two assemblages from horizon V (G-824.0' and G-825.0') are correlated at the 0.67 level and referred to as the Mesolobus Community.

The Transitional Community has greater similarity (correlates at the 0.75 level) with the Glabrocingulum Community than it does with the Cleiothyridina Community. All three of these communities (Glabrocingulum, Transitional and Cleiothyridina) are correlated at the 0.67 level which is the same level at which the two assemblages are related to form the Mesolobus Community. These three former communities are more similar to each other than any one of them is to the latter community. This is indicated by the correlation of the three communities with the Mesolobus Community at the 0.07 level.

The stratigraphic positions and relationships between these four residual fossil communities are shown in Plate II.

Glabrocingulum Community

Stratigraphically, this is the lowest of the four communities and has a diversity index of 8.38 (table 2). It is represented by 11 of the 19 fossil assemblages studied. These 11 assemblages are from Sections C, E, F, G and H, but this community is also probably present in the upper parts (claystone) of Sections A, B and D (Plate II). Stratigraphically, this community occurs in the lower claystone. It might have been found along the margins of a restricted bay and/or delta front area of Late Des Moines time. Clay-sized material dominated the substrate of such areas with very little, if any, silt to sand size material. With a mud bottom and shallow water depths turbulence was probably high. Energy,

Table 2

Nature and Composition of *Glabrocingulum* Community

Taxonomic Entity	Avg. No. of Indiv.	Percent of Indiv.	Percent Artic.	Percent BV or LV	Percent Broken
Ammobaculites sp.	2114.5	6.1	-	-	-
Ammodiscus sp.	3601.0	10.5	-	-	-
Bathysiphon sp.	972.0	2.8	-	-	-
Earlandinita sp.	831.8	2.4	-	-	-
Endothyranella sp.	2665.0	7.7	-	-	-
Lituotuba sp.	651.6	1.9	-	-	-
Reophax sp.	2362.0	6.9	-	-	-
Tolypammina sp.	135.5	0.4	-	-	-
Sponge spicules	30.5#		-	-	-
Conularia cf. *C. crustula*	0.2	<0.001	-	-	-
Lingula cf. *L. carbonaria***	439.4	1.3	70.0	?	55.0
Lindstroemella cf. *L. patula***	4.5	0.013	100.0		54.5
*Crurithyris planoconvexa***	1083.0	3.1	78.1	17.4	47.6
*Mesolobus decipiens***	48.0	0.14	93.8	12.5	37.8
*Mesolobus euampygus***	39.3	0.11	85.2	25.0	22.2
Plagioglypta sp.**	1873.0	5.4	-	-	100.0
Allorisma sp.	0.5	0.001	-	-	-
*Anthraconeilo taffiana***	2157.0	6.3	99.1	18.2	40.4
Astartella cf. *A. concentrica***	12.3	0.03	43.3	25.0	73.3
Aviculopecten sp.	0.09	<0.001	-	-	-
*Nuculopsis (Palaeonucula) anodontoides***	1287.3	3.7	89.7	5.0	30.8
*Nuculopsis (Palaeonucula) wewokana***	2351.0	6.8	90.4	58.2	4.4
*Nuculopsis girtyi***	10.8	0.03	83.7	32.1	10.3
*Paleyoldia glabra***	161.8	0.5	99.2	0.0	85.5
*Polidevica bellistriata***	369.0	1.1	90.3	38.2	46.5

Table 2--(Continued)

Taxonomic Entity	Avg. No. of. Indiv.	Percent of Indiv.	Percent Artic.	Percent BV or LV	Percent Broken
Euphemites carbonarius**	1138.0	3.3	-	-	30.9
Girtyspira sp.	56.7	0.16	-	-	12.5
Glabrocingulum (Ananias) grayvillensis**	4055.0	11.8	-	-	58.4
Ianthinopsis sp.**	663.0	1.9	-	-	7.6
Meekospira peracuta**	877.0	2.5	-	-	80.6
Pseudozygopleurids**	940.0	2.7	-	-	0.0
Trepospira depressa**	2644.0	7.7	-	-	59.4
Pseudorthoceras sp.**	43.0	0.13	-	-	100.0
Gastrioceras sp.**	695.0	2.02	-	-	32.4
Amphissites sp.	16.6	0.05	100.0		0.0
Bairdia sp.	55.6	0.16	100.0		0.0
Cavellina sp.	2.6	0.007	100.0		0.0
Healdia sp.	24.5	0.07	100.0		0.0
Moorites sp.	1.6	0.005	100.0		0.0
Crinoid debris	3158.0#				100.0
Echinoid debris	1749.0#				100.0
Holothurian debris	1311.0#				100.0
Ophiuroid and/or Asteroid debris	5523.0#				100.0
Scolecodonts	81.4#				
Conodonts	180.1#				
Fish debris	98.9#				
Faecal pellets	7990.0#				

Diversity Index = DI
N = Number of Species = 38
n = Number of Individuals = 34383

$$DI = \frac{N}{\log n} = 8.38$$

for transportation and winnowing, was probably low to moderate since most of the benthic invertebrates are represented by numerous small individuals. Some forms, interpreted as "foreign" to this community, are present. These were probably transported into the area as evidenced by their fragmental nature and low densities (small numbers of individuals and/or fragments). If the environmental placement is correct (i.e., shallow, nearshore) then salinities could have been altered by fresh water runoff.

Biotic Elements

Indigenous Forms. The nature and composition of the Glabrocingulum Community is represented in Table 2 (notations are as defined in Appendix III). Some representative fossils of this community are illustrated on Plate IV (figs. 1, 2, 6, 11, 13, 15, 17, 18, 20, 21, 24, 25 and 28). Dominating the community are the molluscans with Glabrocingulum (Ananias) grayvillensis the most abundant organisms, 11.8% (hence the community name). The gastropod, Trepospira depressa, 7.7%, is the second most abundant organism. Other snails, Euphemites carbonarius, Girtyspira sp., Ianthinopsis sp., Meekospira peracuta, and pseudozygopleurids are also present. While the gastropods dominate this community, pelecypods are also common components. Nuculopsis (Palaeonucula) wewokana, Anthraconeilo taffiana and Nuculopsis (Palaeonucula) anodontoides are the most abundant clams. Other molluscans are the nekto-planktonic cephalopods and the benthonic scaphopods. Most of these latter two groups have suffered severe post-mortem effects.

Brachiopods are represented by Crurithyris planoconvexa, Lingula cf. L. carbonaria, Mesolobus decipiens, Mesolobus euampygus and

Lindstroemella cf. L. patula in the order of abundance. Foraminifers are represented by eight genera and ostracodes by five. Tolypammina sp. and an occasional orbiculoid brachiopod occur as epizoans on the other benthic members of the community. This foraminifer is commonly found on articulate brachiopods, some snails and crinoid columnals. The orbiculoid is only found on the brachial valves of the chonetoids. Conularids form less than 0.001% of the total community and are the only coelenterates considered as part of this community.

Fragmented and/or disassociated biotic elements considered part of the Glabrocingulum Community are sponges, crinoids, echinoids, ophiuroids and/or asteroids, holothurians, polychaete worms (scolecodonts) and fish. Some of these were probably transported into the community but the nature of preservation, diversity and abundance of various skeletal parts (particularly of the echinoderms) indicates that some of each were components of this community.

Transported Forms. These are the forms which the author feels were not members of the community as it existed at the time of deposition. This is based on the fragmental nature of the forms, the general nature of preservation and their scarcity in the assemblage. These forms are excluded from Table 2, but the contribution each makes to the total assemblage is given in Table 3. The average numbers reported in this table are based on the total number of each entity in the 11 assemblages. Based on a knowledge of the other communities, these transported forms were carried in from more offshore areas. Most of them are members of the Transitional and/or Cleiothyridina Communities.

Table 3

Transported Biotic Elements in the
Glabrocingulum Community

Taxonomic Entity	Average Number of Individuals
Endothyra sp.	81.5
Fusulina sp.	4.4
Globovalvulina sp.	11.6
Lophophyllum cf. *L. profundum*	2.4
Ramose Bryozoa	12.1
Fistuliporids	1.4
Cleiothyridina orbicularis	1.5
Marginiferid fragments	0.4
Other productoid fragments	11.6
Myalinid fragments	0.09
Schizodus sp.	75.6
Bellerophon (*B.*) cf. *B.* (*B.*) *crassus*	23.6
Knightites (*Cymatospira*) sp.	0.4
Phymatopleura nodosus	0.6
Worthenia sp.	0.09
Mooreoceras sp.	0.09
Metacoceras sp.	0.09
Ditomopyge sp. fragments	3.0
Other Trilobite fragments	2.9
Other ostracodes	2.9

Taphonomic (Post-Mortem) Effects. These are breakage due to predators, scavengers or transportation; transportation away from the *Lebensraum* (life setting); non-preservability of the organism (either there are no preservable hard parts or the skeletal elements are dissolved by solutions) and crushing due to compaction. All of these effects can be pre- or post-burial except the latter one, which is always post-burial. In some cases, alteration of the organism may be the cause of death (breakage of the shell by predators).

Crushing affects both indigenous and transported forms. Crushed forms, not broken, have been considered as unaltered in this study. That is to say, they were not used in the calculation of the percentage of broken individuals (specimens). In this, and the other communities crushing does not seem to have broken the fossils. Forms which always occur broken (scaphopods and orthocones) are not crushed and those crushed (small goniatites, bivalves and snails) are generally unbroken. This taphonomic effect did not severely hamper the investigation.

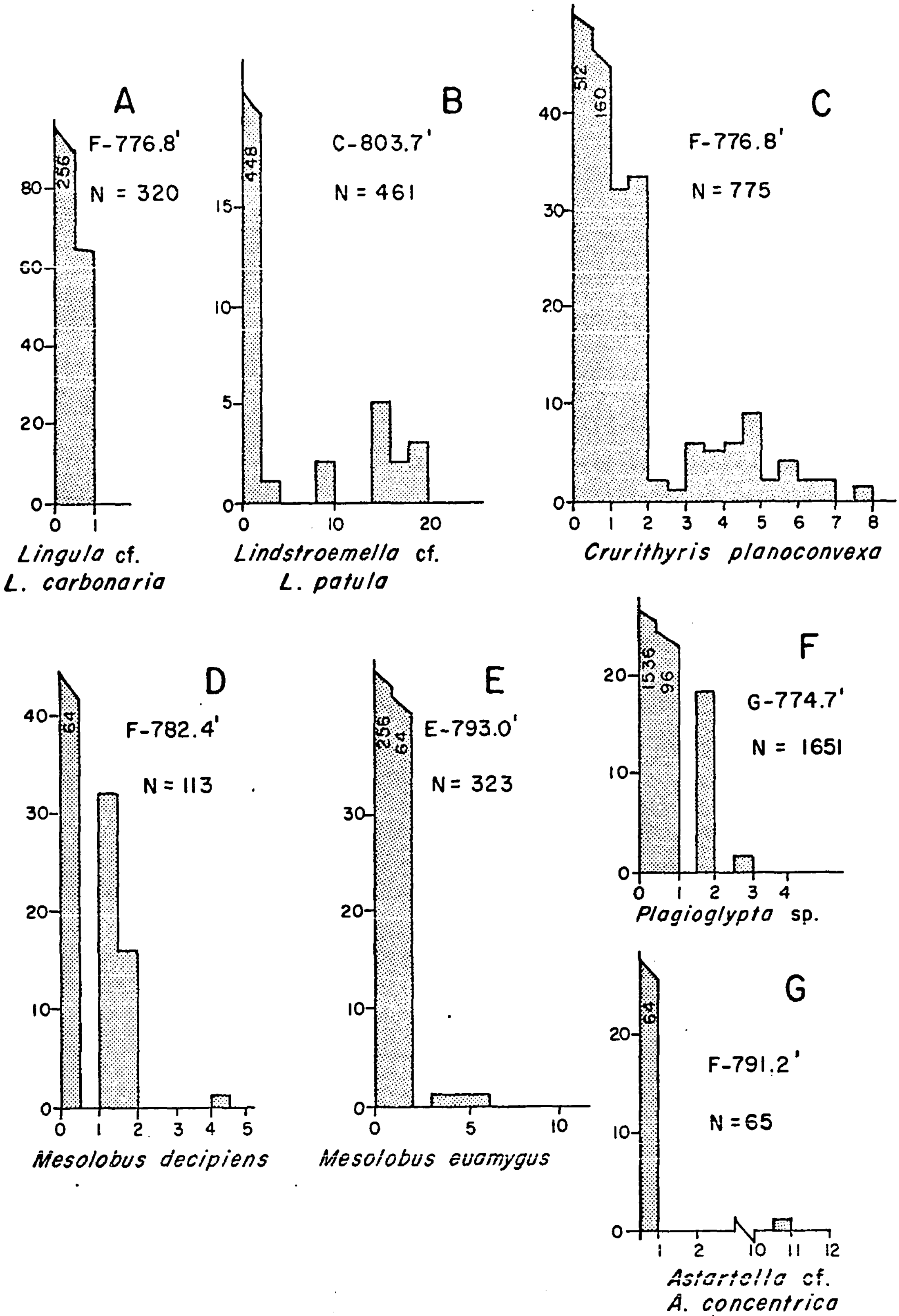
Little, if any, information will ever be available on the soft-bodied organisms which probably constituted more than half of the members of this and the other communities. However, beds of roughly equivalent age (Mazon Creek area of Illinois) contain numerous soft-bodied organisms (Johnson & Richardson, 1966).

Solution of preservable hard parts appears to have had an effect on some of the organisms in this community. Such solution could take place prior to burial or after burial by any waters which were chemically deficient in the constituents composing the skeletons. Chave (1964, p. 386) has shown that chemical durability (solubility) is controlled by the skeletal mineralogy of the organism. Absence of certain size classes from the size-frequency distributions indicates that either solution, transportation, selective predation and/or other effects (i.e., low mortality, recruitment failure, etc.) has been effective in removing individuals of certain sizes. It seems plausible that solution may have been responsible when small size classes are missing or reduced in numbers (figs. 11-D, 12-A and 12-F). Small individuals commonly have thinner, more easily broken shells than larger individuals. To the author's knowledge this has not been suggested nor established in the literature and he has no direct evidence to support the idea, which is based on experience in studying and handling shells of many different forms, both fossil and Recent.

Transportation could also be responsible for removal of some of the various size classes. Figures 11-B, 11-G, 12-E, 13-D and 14-A are a few in which those forms, composing the middle part of the size-frequency distribution, have either been completely removed or reduced in numbers. Transportation depends on the hydrological conditions of the environment and on the hydrodynamical properties of the shells. Both of these can vary with time and with the size and shape of the shells. Work by Nagle (1954, p. 353; 1967, p. 1127) would indicate that juvenile specimens of some invertebrates possess hydrodynamic properties different from those of the adult.

Selective predation by certain predators within a community might also alter the size-frequency distributions. The main predator of pelecypods and possibly of brachiopods during the Paleozoic were probably the asteroids. Among Recent asteroids there are two types of feeding behavior, intraoral and extraoral (Carter, 1968, p. 44-45). Intraoral types eat large numbers of small snimals whole. Fleshy parts are digested by the echinoderm and the empty shells and/or fragments are ejected through the mouth. Extraoral types extrude the stomach into the prey and in the case of the bivalves must first force the valves apart.

Figure 11. Size-frequency distributions of brachiopods, scaphopods and pelecypods from the Glabrocingulum Community (ordinate is frequency, numbers of individuals; abscissa is size in millimeters; letter prefixed numbers refer to collecting stations; N = total number of individuals in the distribution).


A
F-776.8'
N = 320
256
Lingula cf.
L. carbonaria
B
C-803.7'
N = 461
448
Lindstroemella cf.
L. patula
C
F-776.8'
N = 775
512
160
Crurithyris planoconvexa
D
F-782.4'
N = 113
64
Mesolobus decipiens
E
E-793.0'
N = 323
256
64
Mesolobus euamygus
F
G-774.7'
N = 1651
1536
96
Plagioglypta sp.
G
F-791.2'
N = 65
64
Astartella cf.
A. concentrica

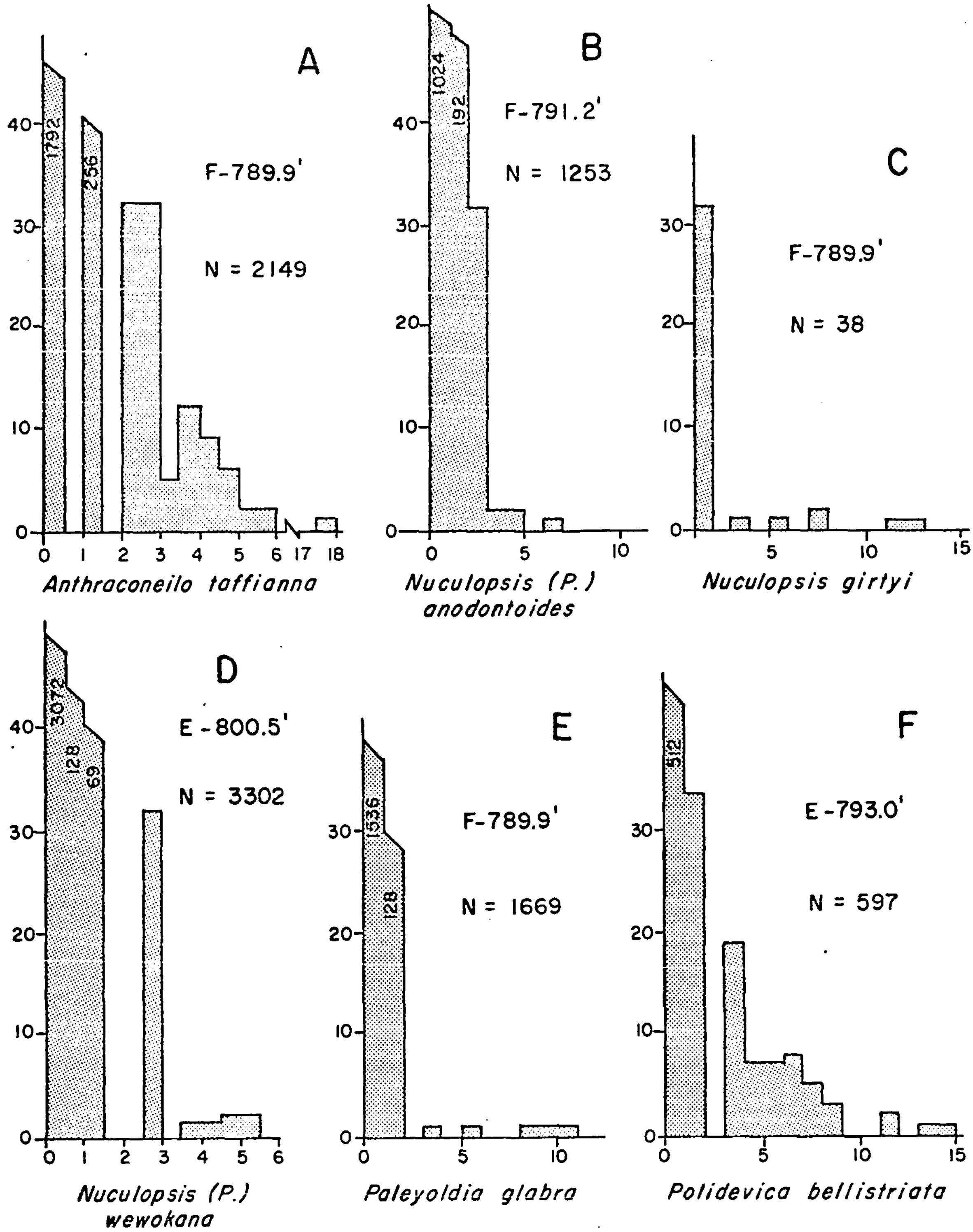


Figure 12. Size-frequency distributions of pelecypods from the Glabrocingulum Community (ordinate is frequency, numbers of individuals; abscissa is size in millimeters; letter prefixed numbers refer to collecting stations; N = total number of individuals in the distribution).

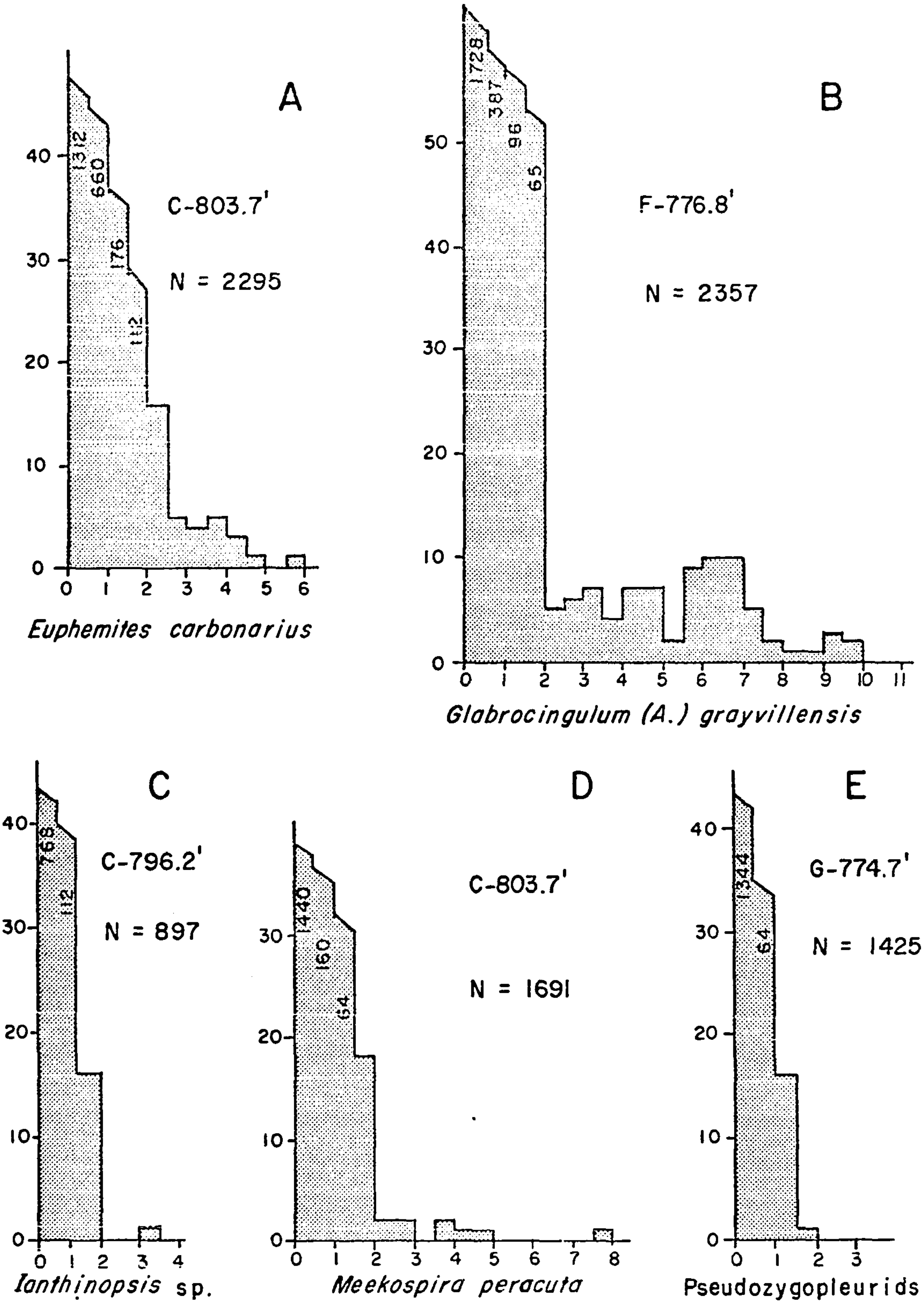


Figure 13. Size-frequency distributions of gastropods from the Glabrocingulum Community (ordinate is frequency, numbers of individuals; abscissa is size in millimeters; letter prefixed numbers refer to collecting stations; N = total number of individuals in the distribution).

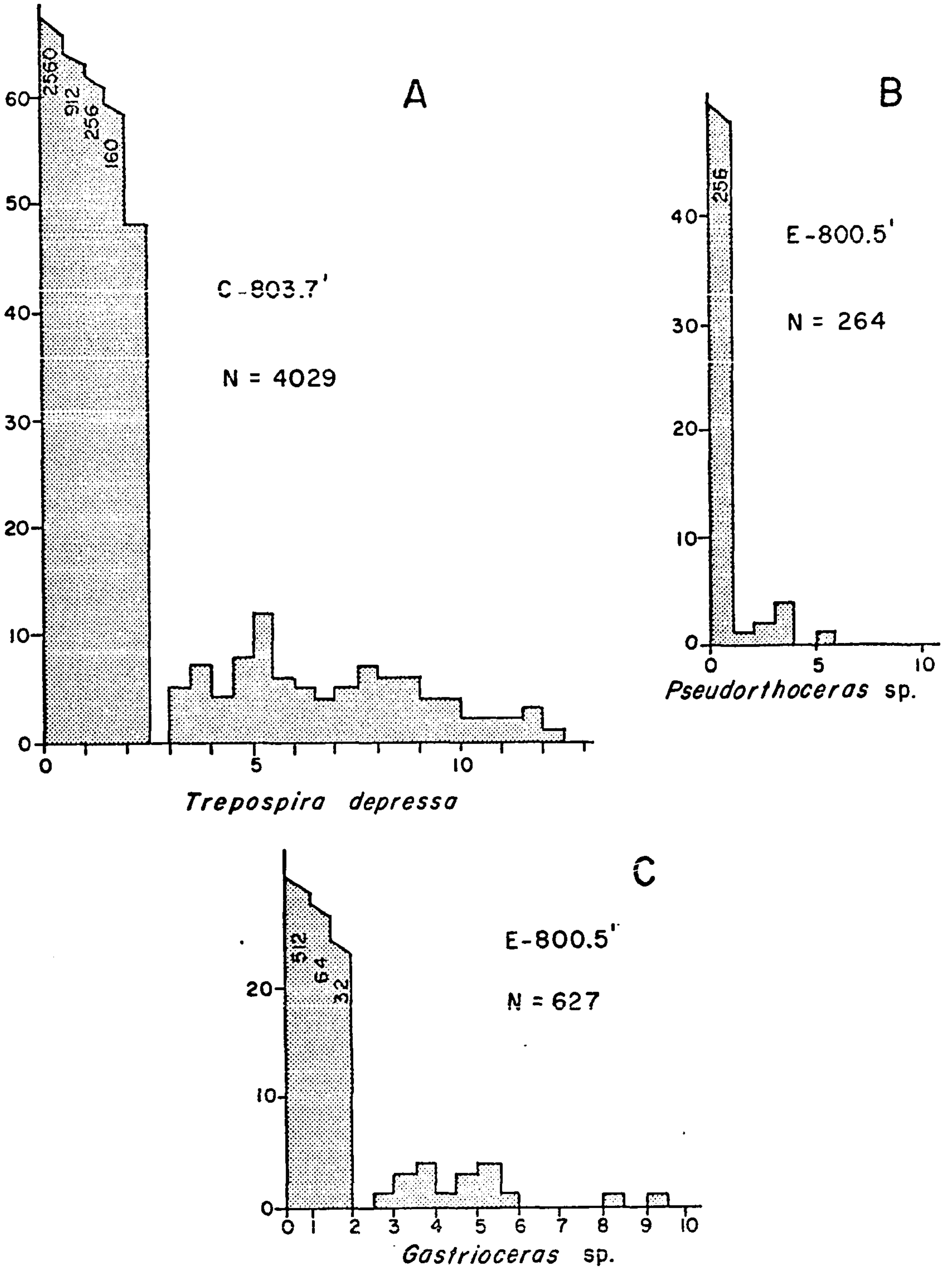


Figure 14. Size-frequency distributions of gastropods and cephalopods from the Glabrocingulum Community (ordinate is frequency, numbers of individuals; abscissa is size in millimeters; letter prefixed numbers refer to collecting stations; N = total number of individuals in the distribution).

This feeding action could also result in the fragmentation of the shells. Carter (1968, pl. I, fig. 6) illustrates a specimen of Venerupis pullastra that was broken by an extraoral feeding asteroid. Some, but not all, of the shells of ingested invertebrates might be fragmented by passage through the digestive tracts of intraoral feeders.

While not all breakage is attributed to predation, it is plausible that some of it occurred in this fashion. There is no direct evidence, such as holes drilled by predaceous snails, in this or the other communities that predators and scavengers have damaged the shells. The fact that certain predators and scavengers are present (cephalopods, echinoids, asteroids, ophiuroids and fish) is sufficient grounds to expect that some breakage was a result of these factors. Transportation could not have broken all the specimens in assemblages where size-frequency distributions are generally positively skewed.

Transportation agents could have been a significant cause of breakage in the Glabrocingulum Community. Due to the shallow water near-shore environment postulated for this community, wave action would certainly be sufficient to break the skeletons of most invertebrates after death.

Specimens of the Recent gastropod Littorina littoreas collected along the intertidal area of Buzzards Bay were examined to determine the amount of breakage that might be due to wave action. This species is morphologically similar to Glabrocingulum and Trepospira in that it has a low spire (high spiral angle). Unlike the two fossil snails it has little or no ornamentation. Littorina littoreas lives in the intertidal to subtidal areas of Buzzards Bay, so the dead forms collected were probably near their Lebensraum. Forms which were obviously drilled were not considered as broken. This eliminated breakage due to one type of predator. Although other predators and/or scavengers may have broken some of the remaining individuals, they are, nevertheless considered as being broken by physical (waves, currents, etc.) factors. From a total of 152 specimens, collected in less than one square meter, 32.2% was broken. This is lower than the percentages (58.4% for Glabrocingulum and 59.4% for Trepospira) of broken individuals of the fossil genera, but it does indicate that breakage is possible in or near the actual environment of the organisms.

The high percentages of broken individuals of scaphopods (Plagioglypta sp.) and straight nautiloids (Pseudorthoceras sp.) may be due to a combination of their gross skeletal morphology and mode of life. Morphologically, both are tapering cones. The former is a bottom-dwelling deposit feeder and/or scavenger and the latter a nekto-planktonic predator. The small end of the scaphopod cone is interpreted as having projecting above the bottom with the larger end (containing the bulk of the soft anatomy, food gathering organs) below the sediment-water interface. This orientation would make the organism available to predators (as a breaking agent) and also to currents and waves after a natural death. The orthocone, being a nekto-planktonic predator, is available to other nekto-planktonic predators. Perhaps the major cause of breakage is due to the instability of such skeletal morphological types in this environment. A simple conical structure may not be able to withstand the wave and current action as well as other geometric shapes.

In general epifaunal forms have a higher percentage of broken individuals than do the infaunal organisms, Table 2. This is to be expected since infaunal forms are protected by the sediment in which they live, while epifaunal animals are more exposed.

It is difficult to separate the causes of breakage in skeletal elements without some direct biological evidence (predator-prey relationships).

Community Structure

Discussion of community structure will be in terms of the feeding types and modes of life of the community members. This information is provided for each member of the Glabrocingulum Community in Table 4. Basically there are four feeding types: those that feed on particulate matter, suspension feeders, deposit feeders and predators. Modes of life are epifaunal and infaunal.

Particulate feeders are those organisms that feed largely on particulate organic matter. Foraminifers eat large amounts of such organic material (Phleger, 1960, p. 111) and are the principal members of this category. This particulate matter may be spores, pollen, algae, various stages of invertebrate larvae or, most importantly, complex organic molecules (nutrients). Such food may be taken from suspension in the water mass or from detritus on the sea bottom. There are also other (taxonomically higher) invertebrates which feed on this particulate organic matter (suspension and deposit feeders). In this study particulate feeders refer only to the so-called microfossils (foraminifers and ostracodes).

Table 4

Feeding Type and Mode of Life of the Members of the Glabrocingulum Community

Taxonomic Entity	Feeding Type	Mode of Life
Ammobaculites sp.	Particulate Matter	Epifaunal (Benthic)
Ammodiscus sp.	Particulate Matter	Epifaunal (Benthic)
Bathysiphon sp.	Particulate Matter	Epifaunal (Benthic)
Earlandinita sp.	Particulate Matter	Epifaunal (Benthic)
Endothyranella sp.	Particulate Matter	Epifaunal (Benthic)
Lituotuba sp.	Particulate Matter	Epifaunal (Benthic)
Reophax sp.	Particulate Matter	Epifaunal (Benthic)
Tolypammina sp.	Particulate Matter	Epizoan (Sessile)
Sponge spicules	Cemented Suspension	Epifaunal (Sessile)
Conularia cf. C. crustula	Vagrant Suspension?	Nekto-Planktonic
Lingula cf. L. carbonaria**	Burrow-Dwelling Suspension	Infaunal (Sessile)
Lindstroemella cf. L. patula**	Cemented Suspension	Epifaunal (Sessile)
Crurithyris planoconvexa**	Pedunculate Suspension	Epifaunal (Sessile)
Mesolobus decipiens**	Spiny Suspension	Epifaunal
Mesolobus euampygus**	Spiny Suspension	Epifaunal
Plagioglypta sp.**	Bottom-Dwelling Deposit & Scav.	Infaunal
Allorisma sp.	Attached Suspension	Epifaunal
Anthraconeilo taffiana**	Labial-palp Deposit	Infaunal
Astartella cf. A. concentrica**	Non-Siphonate Suspension	Infaunal
Aviculopecten sp.	Vagrant Suspension	Nekto-Planktonic
Nuculopsis (Palaeonucula) anodontoides**	Labial-palp Deposit	Infaunal
Nuculopsis (Palaeonucula) wewokana**	Labial-palp Deposit	Infaunal
Nuculopsis girtyi**	Labial-palp Deposit	Infaunal
Paleyoldia glabra**	Labial-palp Deposit	Infaunal
Polidevica bellistriata**	Labial-palp Deposit	Infaunal

Table 4--(Continued)

Taxonomic Entity	Feeding Type	Mode of Life
Euphemites carbonarius**	Vagrant Browsers & Deposit	Epifaunal
Girtyspira sp.	Vagrant Browsers & Deposit	Epifaunal
Glabrocingulum (Ananias) grayvillensis**	Vagrant Browsers & Deposit	Epifaunal
Ianthinopsis sp.**	Vagrant Browsers & Deposit	Epifaunal
Meekospira peracuta**	Vagrant Browsers & Deposit	Epifaunal
Pseudozygopleurids**	Vagrant Browsers & Deposit	Epifaunal
Trepospira depressa**	Vagrant Browsers & Deposit	Epifaunal
Pseudorthoceras sp.**	Vagrant Predators	Nekto-Planktonic
Gastrioceras sp.**	Vagrant Predators	Nekto-Planktonic
Amphissites sp.	Bottom-Dwelling Deposit & Scav.	Nekto-Planktonic to Infaunal
Bairdia sp.	Bottom-Dwelling Deposit & Scav.	Nekto-Planktonic to Infaunal
Cavellina sp.	Bottom-Dwelling Deposit & Scav.	Nekto-Planktonic to Infaunal
Healdia sp.	Bottom-Dwelling Deposit & Scav.	Nekto-Planktonic to Infaunal
Moorites sp.	Bottom-Dwelling Deposit & Scav.	Nekto-Planktonic to Infaunal
Crinoid debris	Rooted Suspension	Epifaunal (Sessile)
Echinoid debris	Vagrant Browsers, Deposit & Scav.	Epifaunal to Infaunal?
Holothurian debris	Bottom-Dwelling Deposit & Scav.	Infaunal
Ophiuroid &/or Asteroid debris	Vagrant Browsers, Deposit & Pred.	Epifaunal
Scolecodonts	Burrow-Dwelling Suspension	Infaunal (Sessile)
Conodonts	?	?
Fish debris	Vagrant Predators	Nekto-Planktonic

For purposes of this investigation suspension feeders are those that obtain food from the suspended matter in the water mass irrespective of the method they employ to capture it. No distinction is made between filter-feeders and other forms which feed on particulate matter suspended in the water. This group includes sponges, corals, bryozoans, brachiopods, some pelecypods, polychaetes and crinoids.

Those organisms which obtain their food from the bottom sediments or deposits are here termed deposit feeders. Hunt (1925, p. 567-568) defined deposit feeders as:

> . . . those which feed upon the detritus deposited on the bottom, and on its associated micro-organisms.

This is the way the term is used in this paper. No attempt has been made to differentiate between selective and non-selective deposit feeders as was done by Sanders (1956, p. 339) in communities of Recent organisms. Deposit feeders include certain pelecypods (nuculoids), all the gastropods, scaphopods, trilobites, ostracodes, holothurians, echinoids, ophiuroids and asteroids.

Lastly are the predators or carnivores. This is a small group and excludes all sessile and small vagrant organisms which take live prey from the water mass. Coelenterates may secure certain zooplankton (live prey) from suspension. Foraminifers and ostracodes probably obtain small zooplankton and bacteria from the water mass. These forms, and others like them, are not included as predators. Predators are then, larger invertebrates which feed on other invertebrates by taking them alive. While scavengers are those organisms which eat only dead and decaying animals, it is difficult to separate them from predators when considering invertebrates. For example, some echinoderms are both predators and scavengers as are some gastropods. In this investigation predators include echinoids, asteroids, ophiuroids, cephalopods and fish (sharks).

Any attempt to group fossil, or Recent, invertebrates into feeding types is largely artificial because of overlap. Certain invertebrates may be suspension feeders part of the time and deposit feeders at other times depending on what food is available. For this reason certain groups are included in more than one feeding type (ostracodes). Others (holothurians) are listed in only one category, the one that the present author feels is the primary one in terms of the environments involved.

Assignment of modes of life to the various taxonomic groups is simpler but there is still overlap between the various modes. The only preserved vagrant infaunal elements are the nuculoid pelecypods, holothurians and scaphopods. Lingula and polychaete worms are classed as sessile infaunal benthos. Epifaunal organisms (sponges, corals, bryozoans, some brachiopods and crinoids) are referred to as sessile benthos. Trilobites, echinoids, ophiuroids, asteroids and most snails are termed vagrant benthos. Nekto-planktonic forms include pectens, conularids, cephalopods and fish (sharks).

Overlap between in- and epifaunal elements occurs in groups such as ostracodes, echinoids, trilobites, holothurians and gastropods. The ostracodes can and do swim, but they also crawl on and burrow into the bottom. The other four groups move along the bottom surface and at times plow into the upper layers of it until they are partial or completely buried (infaunal).

Table 5 shows the percentages of each of the four feeding types and of the modes of life of the species in the Glabrocingulum Community. The 38 species used to calculate the diversity index are the only ones used in arriving at the figures in this table. Similar tables for the other communities were prepared in the same way. In order to obtain this table it was necessary to arbitrarily place certain taxonomic groups in

Table 5

Percentages of Species of Each Feeding Type and Mode of Life in the Glabrocingulum Community

Feeding Types	Particulate	21.05%	
	Suspension	28.95%	
	Deposit	44.74%	
	Predator	5.26%	
Modes of Life	Epifaunal	60.53%	(30.43% are nekto-planktonic)
	Infaunal	39.47%	

specific categories for feeding and mode of life. This same placement has been used for similar calculations on the other communities. Foraminifers alone are considered as particular feeders. The total number of ostracode taxa are split equally between infaunal and nekto-planktonic forms and deposit and suspension feeders. Gastropods are considered as epifaunal deposit feeders and the others are as indicated in Table 4.

Figure 22-A is a graphic representation of the date given in Table 5. From this information it is obvious that the Glabrocingulum Community is dominated, in terms of species, by epifaunal deposit feeders. Approximately half of the epifaunal forms are nekto-planktonic with the remainder being either sessile or vagrant benthos.

The fact that deposit feeding is the dominant type is reasonable since the substrate was mud and the waters turbid. Turbid waters are not extremely favorable sites for suspension feeders. Sanders (1956, Table IX) in his study of the bottom communities of Long Island Sound shows a total of 94.07% deposit feeders in areas where the percentage of silt and clay is 65.0% and only 5.78% suspension feeders. This data for the Glabrocingulum Community lacks information on the soft-bodied organisms which was available to Sanders. In spite of this, there is still a similarity in that the percentage of suspension feeders is approximately half that of the deposit feeders.

The number of predaceous species is low as compared to the other feeding types. This is to be expected in a natural community. Particulate feeders (foraminifers) are intermediate (below the suspension feeders). One of the most significant predators was not considered in these figures because of the fragmented nature of its remains. Carter (1968) has indicated that, for pelecypods, the asteroids are and probably were the most important predatory group. Also the fishes (sharks) have not been included in these figures for the same reason.

If the nekto-planktonic forms are removed, since they are not actually parts of the benthic communities, from the epifaunal elements there are 30.10% of the species which are sessile or vagrant benthos. Comparing this to the infaunal species (39.47%) we see that this community is actually dominated by infaunal elements. Sanders (1956, p. 399) indicates the animals he placed in each feeding group and most of these are infaunal forms. It would seem, then, that the Glabrocingulum Community was actually dominated by infaunal deposit feeders and was not unlike bottom communities of present-day seas with similar environmental conditions.

Transitional Community

This community is represented by two assemblages (E-826.0' and E-827.2') and is stratigraphically the next higher community. In the collections for this study it was only found at Section E but it is also probably represented in bed 20 of Section F and in the middle part of bed 12 of Section G. It has a diversity index of 8.14 (table 6) which is slightly lower than the one for the Glabrocingulum Community. The 40 species of this community are represented by 82,093 individuals, the most individuals of the four communities.

Mixture of taxonomic types from the underlying Glabrocingulum Community with those of the overlying Cleiothyridina Community is the reason for referring to this community as transitional. As discussed in a previous section,. the nature of the lithologies, fossil assemblages and depositional environments in this claystone interval are gradational. The same thing would be found if a single horizon were examined that represented a gradation between nearshore and more offshore conditions. There would be an overlap of communities where elements of both would occur together.

The Transitional Community occurs in the upper part of the lower claystone and lower part of the middle claystone units. It could be intermediate between the suggested restricted bay and/or delta front areas of the Glabrocingulum Community and the more open bay and/or pro-deltal areas suggested later for the Cleiothyridina Community. Figure 10, the dendrogram, indicates there is more similarity between this community and that of Glabrocingulum than with the Cleiothyridina Community.

Material of clay-size is again dominant in the substratum. Turbulence was probably still quite high but not as high as in the Glabrocingulum Community. Water depths were possibly slightly deeper than those of the nearer shore Glabrocingulum Community. Energy may have been about the same as for the community characterized by Glabrocingulum. There are great numbers of small individuals of certain organisms hence there may not have been amply energy available for transportation within the community. Some few forms, interpreted as "foreign", are considered to have been transported into this community. Salinities in this environment were probably more constant, less variable, because, if the environmental placement is correct, the area is a little farther from shore and would be affected less by freshwater runoff.

Biotic Elements

Indigenous Forms. Table 6 (notations are as defined in Appendix III) represents the nature and composition of the Transitional Community. Some representative fossils of this community are illustrated on Plate IV (figs. 8, 9, 14, 16 and 26). Molluscans are again the dominant organic group in both numbers and diversity. The pseudozygopleurid snails are the most abundant group of molluscans (4.3%) with Trepospira depressa and Meekospira peracuta second and third (3.5% and 3.3%), respectively. Glabrocingulum (Ananias) grayvillensis is only 2.9% of the community. There are three new gastropod genera: Knightites, Straparolus and Bellerophon.

Table 6

Nature and Composition of Transitional Community

Taxonomic Entity	Avg. No. of Indiv.	Percent of Indiv.	Percent Artic.	Percent BV or LV	Percent Broken
Ammobaculites sp.	29344.0	35.7	-	-	-
Ammodiscus sp.	4672.0	5.7	-	-	-
Bathysiphon sp.	3264.0	4.0	-	-	-
Earlandinita sp.	6144.0	7.5	-	-	-
Endothyranella sp.	6448.0	7.9	-	-	-
Globovalvulina sp.	320.0	0.4	-	-	-
Lituotuba sp.	864.0	1.05	-	-	-
Reophax sp.	1280.0	1.6	-	-	-
Tolypammina sp.	3936.0	4.8	-	-	-
Lophophyllum cf. L. profundum	6.0	0.007	-	-	100.0
Ramose Bryozoa	1455.0	1.77	-	-	100.0
Lindstroemella cf. L. patula	129.0	0.16	100.0		50.0
Cleiothyridina orbicularis	3.0	0.004	*	*	*
Crurithyris planoconvexa**	2141.0	2.6	50.3	11.8	64.8
Mesolobus euampygus**	749.0	0.9	56.8	94.3	34.2
Plagioglypta sp.**	667.0	0.8	-	-	100.0
Anthraconeilo taffiana**	353.0	0.43	90.2	25.0	37.9
Astartella cf. A. concentrica**	133.0	0.16	25.3	61.5	77.8
Nuculopsis (Palaeonucula) anodontoides**	391.0	0.48	100.0		11.3
Nuculopsis (Palaeonucula) wewokana**	2007.0	2.4	87.5	20.0	10.3
Nuculopsis girtyi**	37.5	0.05	60.0	50.0	63.6
Paleyoldia glabra	2.0	0.0024	*	*	*
Polidevica bellistriata**	107.0	0.13	74.9	45.0	57.4
Straparolus (Amphiscapha) catilloides**	100.0	0.12	-	-	52.3
Bellerophon (B.) cf. B. (B.) crassus**	1127.0	1.4	-	-	24.1
Euphemites carbonarius**	696.0	0.85	-	-	21.4
Glabrocingulum (Ananias) grayvillensis**	2379.0	2.9	-	-	61.1

Table 6--(Continued)

Taxonomic Entity	Avg. No. of Indiv.	Percent of Indiv.	Percent Artic.	Percent BV or LV	Percent Broken
Ianthinopsis sp.**	1788.0	2.2	-	-	8.3
Knightites (Cymatospira) montfortianum**	51.0	0.062	-	-	80.0
Meekospira peracuta**	2727.0	3.3	-	-	88.0
Pseudozygopleurids**	3525.0	4.3	-	-	0.0
Trepospira depressa**	2851.0	3.5	-	-	61.0
Pseudorthoceras sp.**	22.0	0.027	-	-	100.0
Gastrioceras sp.**	298.0	0.36	-	-	83.3
Trilobite fragments	833.0#				
Amphissites sp.	238.0	0.29	81.8	?	0.0
Bairdia sp.	1280.0	1.6	86.7	?	0.0
Cavellina sp.	113.8	0.14	100.0		0.0
Healdia sp.	384.0	0.5	100.0		0.0
Hollinella sp.	32.0	0.04	100.0		0.0
Moorites sp.	28.4	0.03	100.0		0.0
Crinoid debris	20860.0#				100.0
Echinoid debris	3529.0#				100.0
Holothurian debris	4672.0#				100.0
Ophiuroid &/or Asteroid debris	1360.0#				100.0
Conodonts	1088.0#				
Fish debris	2144.0#				
Faecal pellets	9102.0#				

N = 40; n = 82093; DI = 8.14

There are five pelecypod genera and seven species with Nuculopsis (Palaeonucula) wewokana (2.4%) as the most abundant. These are the same forms present in the Glabrocingulum Community, except Allorisma and Aviculopecten are absent. However, in terms of percentages of individuals they are much less important in this community.

Scaphopods and cephalopods of the nearer shore community are still present, although lower in percentage of individuals.

Crurithyris planoconvexa, Mesolobus euampygus, Lindstroemella cf. L. patula and Cleiothyridina orbicularis, in order of abundance, represent the brachiopods. In terms of percentages of individuals they are about the same as the previously discussed community. Cleiothyridina orbicularis is new and Lingula cf. L. carbonaria and Mesolobus decipiens are absent.

The attached coelenterate, Lophophyllum cf. L. profundum is considered a member of this community as are the attached (now fragmented) ramose bryozoans.

Nine genera of foraminifers and six of ostracodes are represented, with the foraminifer, Ammobaculites, contributing 35.7% to the total individuals of the community. Globovalvulina is the new foraminifer genus and Hollinella the new ostracode genus. According to Lane (1964, p.16) both of these genera belong to a more marine (neritic) environment as compared to the brackish water (nearshore) environment of Ammodiscus. Percentages of individuals of Ammodiscus and Reophax are lower for this community than for the Glabrocingulum Community. Both of these genera are more typical of nearer shore areas (Phleger, 1960).

Trilobites, crinoids, echinoids, ophiuroids, asteroids, holothurians and fish are the remaining organisms that are considered part of the Transitional Community. All of these are fragmented and/or disassociated and it is reasonable to expect some of them to have been transported into the area of this community. But as mentioned for the *Glabrocingulum* Community, the nature of preservation, diversity and abundance of these fragmented and/or disassociated skeletal elements indicates that most of them lived at, or near the collecting site .

Transported Forms. Forms discussed in this section are excluded from the Transitional Community using the same criteria as for the *Glabrocingulum* Community. These taxa are not included in Table 6 but are listed in Table 7. The contribution each makes to the total assemblage is also indicated. These contributions (numbers) are averages of the total numbers of specimens of each entity in the two assemblages. Most

Table 7

Transported Biotic Elements in the Transitional Community

Taxonomic Entity	Average Number of Individuals
?*Acanthocladia* sp.	0.5
Fenestrate bryozoans	0.5
Derbyia cf. *D. crassa*	2.5
Hustedia cf. *H. mormoni*	3.5
Marginiferid fragments	2.5
Neospirifer sp.	0.5
Other Productoid fragments	1249.0
Allorisma sp.	1.0
Bellerophon (*Parkidonotus*) *pericarinatus*	0.5
Phymatopleura nodosus	65.5
Plant debris	3.0

of these transported forms were probably carried in from the more offshore communities, i.e., Cleiothyridina. Allorisma sp. is a member of the Glabrocingulum Community and could have been carried seaward into the Transitional Community.

Taphonomic (Post-Mortem) Effects. These effects have been discussed in conjunction with the Glabrocingulum Community. It is only necessary here to point out the forms in this community which suffered from them. In this study, with the material at hand, it is impossible to separate the biological breakage from that due to physical factors.

Crushing has affected most severely the goniatites in this community. Bivalves, particularly the biconvex forms such as Crurithyris and Cleiothyridina, have also been affected. The former is less affected than the latter. Crushing in Cleiothyridina is perpendicular to the plane of the commissure. In most cases this is also true for Crurithyris. None of the crushing severely hampered identification or sizing procedures.

As in the Glabrocingulum Community, there were probably numerous soft-bodied forms present which were not recorded in the sediments.

Solution, transportation, selective predation and/or other effects have altered the size-frequency distributions of the members of this community. Figures 15-B, 15-D, 15-F, 16-A, 16-C, 16-D, 17-C and 18-C illustrate size-frequency distributions in which one or more size classes are missing or reduced in total numbers. This can be explained in terms of the factors mentioned above and discussed previously. Fortunately, this alteration has not rendered these distributions completely useless.

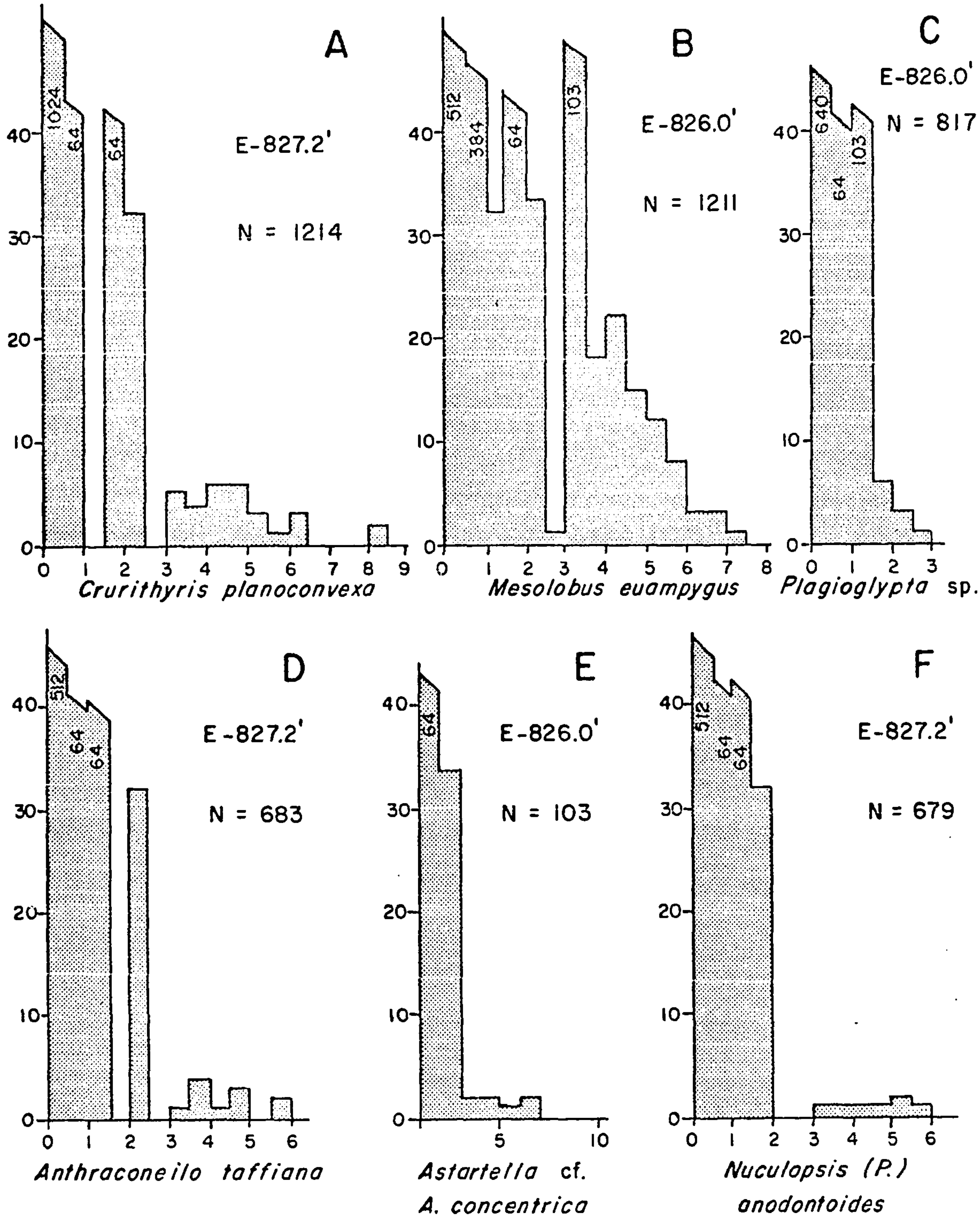


Figure 15. Size-frequency distributions of brachiopods, scaphopods and pelecypods from the Transitional Community (ordinate is frequency, numbers of individuals; abscissa is size in millimeters; letter prefixed numbers refer to collecting stations; N = total number of individuals in the distribution).

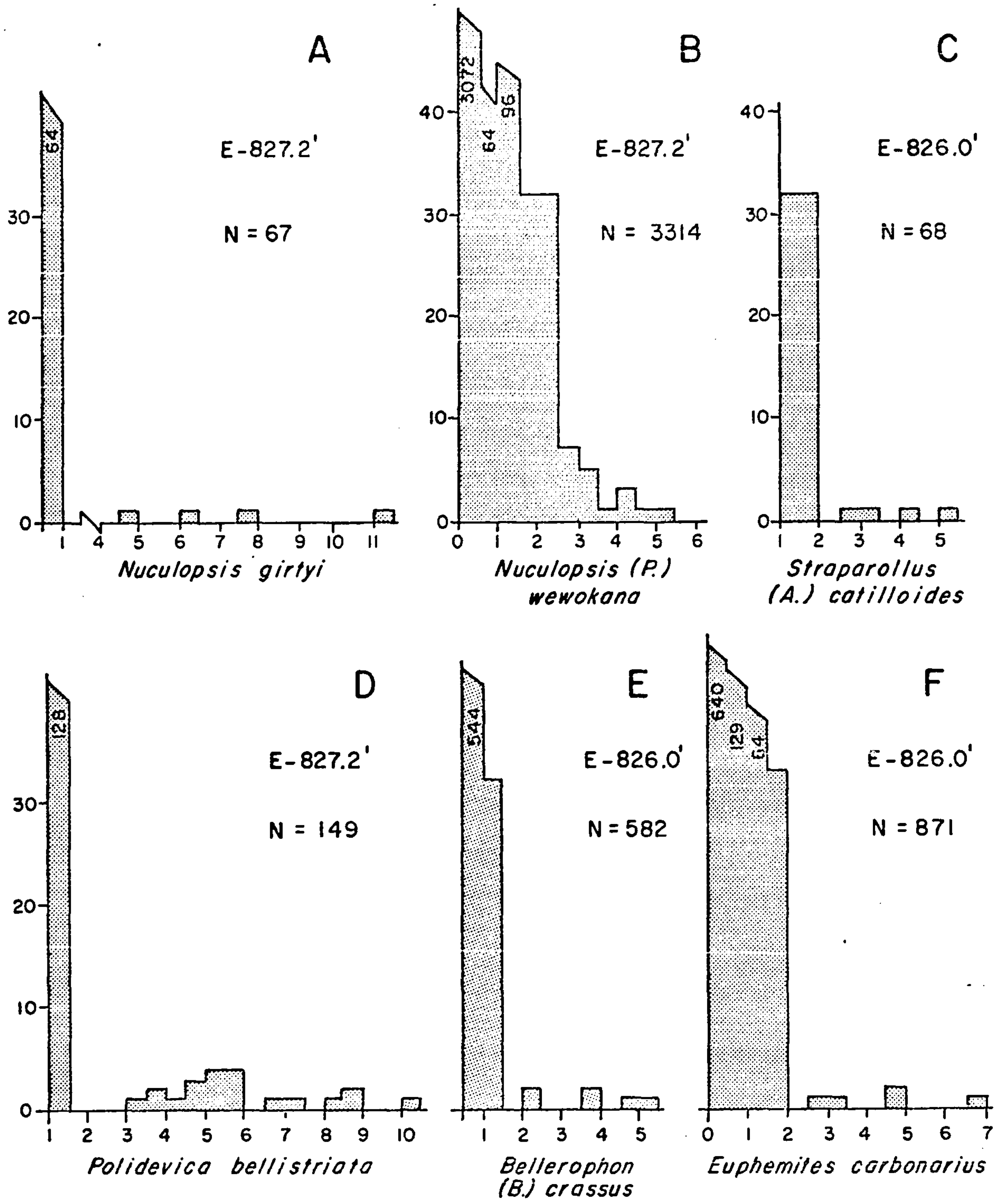


Figure 16. Size-frequency distributions of pelecypods and gastropods from the Transitional Community (ordinate is frequency, numbers of individuals; abscissa is size in millimeters; letter prefixed numbers refer to collecting stations; N - total number of individuals in the distribution).

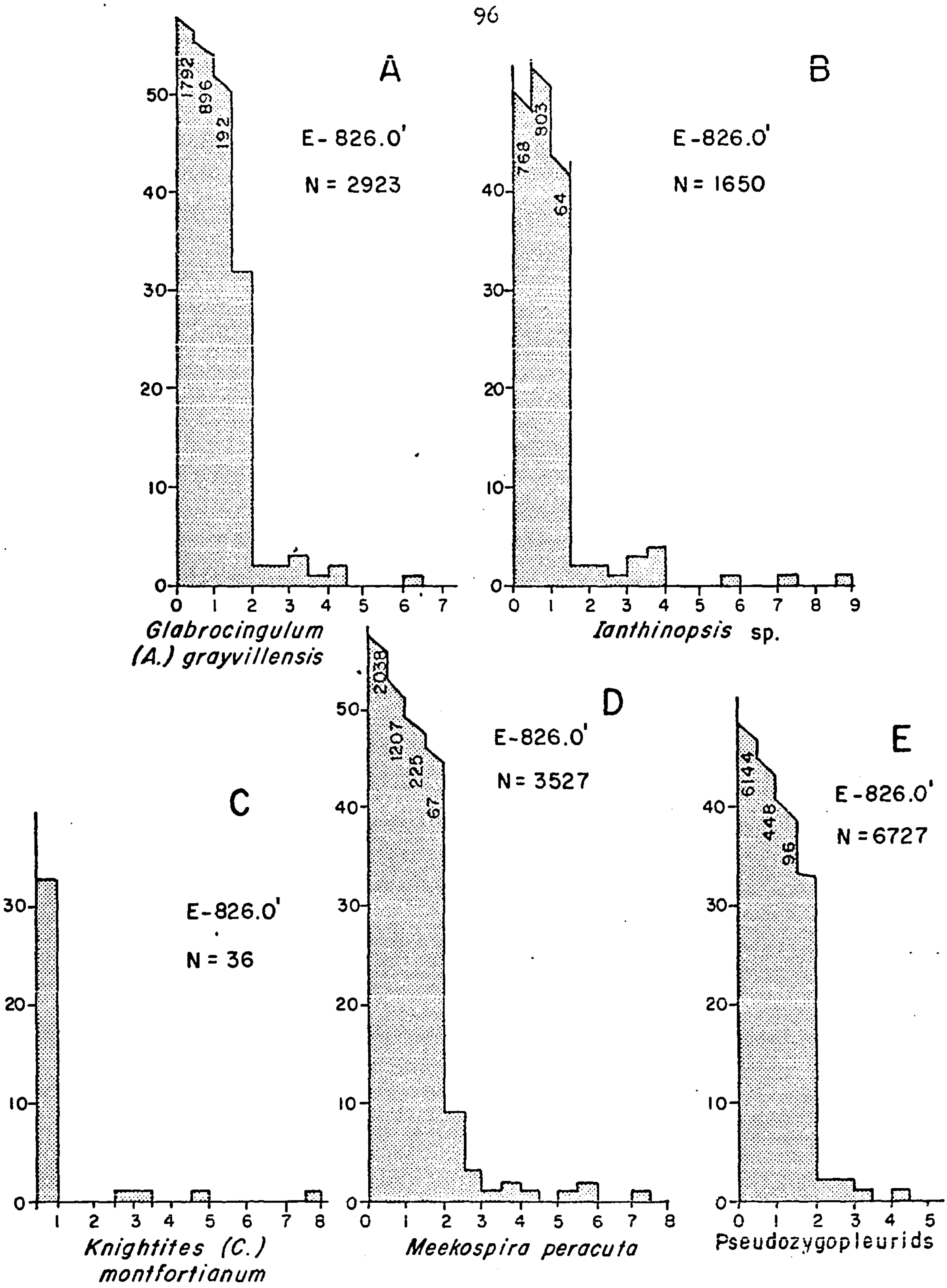


Figure 17. Size-frequency distributions of gastropods from the Transitional Community (ordinate is frequency, numbers of individuals; abscissa is size in millimeters; letter prefixed numbers refer to collecting stations; N = total number of individuals in the distribution).

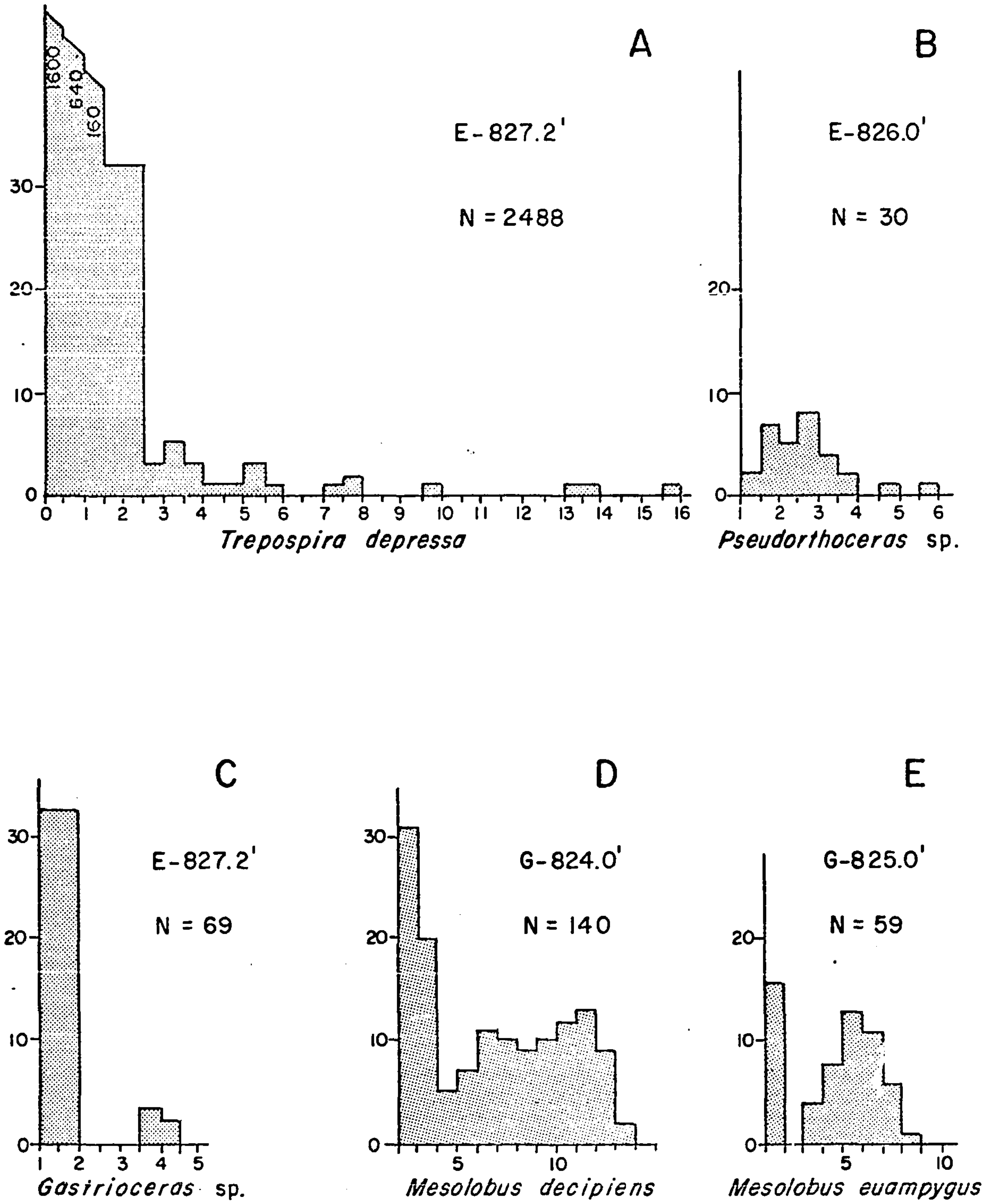


Figure 18. Size-frequency distributions of gastropods and cephalopods from the Transitional Community and of brachiopods from the Mesolobus Community (ordinate is frequency, numbers of individuals; abscissa is size in millimeters; letter prefixed numbers refer to collecting stations; N = total numbers of individuals in the distribution).

Percentages of broken individuals are highest in the corals, scaphopods and orthocones. The methods previously discussed in explaining breakage in the two latter groups are also applicable in this community. Breakage of bryozoans and solitary corals, such as Lophophyllum, is possible through the action of scavengers, predators and/or wave and current action. Predators (fish) are known to nibble on present-day corals and calcareous algae (Wells, 1957, p. 613) to obtain the protected soft parts. This is plausible in ancient seas and particularly in this community since fish fragments are present.

Forms interpreted as epifaunal have a higher percentage of broken individuals than infaunal forms,(i.e., Crurithyris - 64.8%, Glabrocingulum - 61.1%, Knightites - 80.0% and Meekospira - 88.0% compared to Anthraconeilo - 37.9%, Nuculopsis (P.) anodontoides - 11.3%, Nuculopsis (P.) wewokana - 10.3% and Polidevica - 57.4%; see table 6). The presence of animals which are known to be scavengers and predators makes it reasonable to attribute some of the breakage to them. Bivalves with high percentages of broken individuals generally have a low percentage of articulated specimens and vice versa. For example Astartella has 25.3% of the individuals articulated and 77.8% broken while Anthraconeilo has 90.2% articulated and only 37.9% broken. This would support the idea of predator breakage since such organisms would be disarticulated by the predator to obtain the fleshy parts. Of course, this does not apply to drilling snails, but there is no evidence that they are present in this community.

Community Structure

The feeding type and mode of life of each member of this community is given in Table 8. This table is included to provide this ecological information for all members including those fragmented and/or disassociated organisms, which are not included in later considerations. Usage of the four basic feeding types and the two modes of life is discussed in a previous section. Problems of overlap in these categories are handled in the same manner as for the Glabrocingulum Community.

Table 9 is a consolidation of this information for the 40 species considered members of this community. It contains the percentages (in terms of species) that each feeding type and each mode of life contributes to the total community.

This same information is presented graphically in Figure 22-B. From both Table 9 and Figure 22-B it can be seen that this community is not unlike the Glabrocingulum Community. The percentages are about the same for each group. There is a higher percentage of suspension feeding species which is due to the absence of three suspension feeding forms which were present in the Glabrocingulum Community. Predators are low with the most important ones not considered because they are preserved as disassociated skeletal elements and fragments (asteroids and fish). Particulate feeders are slightly higher due to the addition of another species. On the basis of individuals this group would have the highest percentage since one foraminifer genus, Ammobaculites, alone accounts for 35.7% of the total individuals in the community. In terms of feeding types the deposit feeders are still the dominant species, due to the environmental conditions.

Table 8

Feeding Type and Mode of Life of the Members of the Transitional Community

Taxonomic Entity	Feeding Type	Mode of Life
Ammobaculites sp.	Particulate Matter	Epifaunal (Benthic)
Ammodiscus sp.	Particulate Matter	Epifaunal (Benthic)
Bathysiphon sp.	Particulate Matter	Epifaunal (Benthic)
Earlandinita sp.	Particulate Matter	Epifaunal (Benthic)
Endothyranella sp.	Particulate Matter	Epifaunal (Benthic)
Globovalvulina sp.	Particulate Matter	Epifaunal (Benthic)
Lituotuba sp.	Particulate Matter	Epifaunal (Benthic)
Reophax sp.	Particulate Matter	Epifaunal (Benthic)
Tolypammina sp.	Particulate Matter	Epizoan (Sessile)
Lophophyllum cf. L. profundum	Cemented Suspension	Epifaunal (Sessile)
Ramose Bryozoa	Cemented Suspension	Epifaunal (Sessile)
Lindstroemella cf. L. patula	Cemented Suspension	Epifaunal (Sessile)
Cleiothyridina orbicularis	Pedunculate Suspension	Epifaunal (Sessile)
Crurithyris planoconvexa**	Pedunculate Suspension	Epifaunal (Sessile)
Mesolobus euampygus**	Spiny Suspension	Epifaunal
Plagioglypta sp.**	Bottom-Dwelling Deposit & Scav.	Infaunal
Anthraconeilo taffiana**	Labial-palp Deposit	Infaunal
Astartella cf. A. concentrica**	Non-Siphonate Suspension	Infaunal
Nuculopsis (Palaeonucula) anodontoides**	Labial-palp Deposit	Infaunal
Nuculopsis (Palaeonucula) wewokana**	Labial-palp Deposit	Infaunal
Nuculopsis girtyi**	Labial-palp Deposit	Infaunal
Paleyoldia glabra	Labial-palp Deposit	Infaunal
Polidevica bellistriata**	Labial-palp Deposit	Infaunal
Straparolus (Amphiscapha) catilloides**	Vagrant Browsers & Deposit	Epifaunal
Bellerophon (B.) cf. B. (B.) crassus**	Vagrant Browsers & Deposit	Epifaunal

Table 8--(Continued)

Taxonomic Entity	Feeding Type	Mode of Life
Euphemites carbonarius**	Vagrant Browsers & Deposit	Epifaunal
Glabrocingulum (Ananias) grayvillensis**	Vagrant Browsers & Deposit	Epifaunal
Ianthinopsis sp.**	Vagrant Browsers & Deposit	Epifaunal
Knightites (Cymatospira) montfortianum**	Vagrant Browsers & Deposit	Epifaunal
Meekospira peracuta**	Vagrant Browsers & Deposit	Epifaunal
Pseudozygopleurids**	Vagrant Browsers & Deposit	Epifaunal
Trepospira depressa**	Vagrant Browsers & Deposit	Epifaunal
Pseudorthoceras sp.**	Vagrant Predators	Nekto-Planktonic
Gastrioceras sp.**	Vagrant Predators	Nekto-Planktonic
Trilobite fragments	Bottom-Dwelling Deposit & Scav.	Epi-Infaunal
Amphissites sp.	Bottom-Dwelling Deposit & Scav.	Nekto-Planktonic to Infaunal
Bairdia sp.	Bottom-Dwelling Deposit & Scav.	Nekto-Planktonic to Infaunal
Cavellina sp.	Bottom-Dwelling Deposit & Scav.	Nekto-Planktonic to Infaunal
Healdia sp.	Bottom-Dwelling Deposit & Scav.	Nekto-Planktonic to Infaunal
Hollinella sp.	Bottom-Dwelling Deposit & Scav.	Nekto-Planktonic to Infaunal
Moorites sp.	Bottom-Dwelling Deposit & Scav.	Nekto-Planktonic to Infaunal
Crinoid debris	Rooted Suspension	Epifaunal (Sessile)
Echinoid debris	Vagrant Browsers, Deposit & Scav.	Epifaunal to Infaunal?
Holothurian debris	Bottom-Dwelling Deposit & Scav.	Infaunal
Ophiuroid &/or Asteroid debris	Vagrant Browsers, Deposit & Pred.	Epifaunal
Conodonts	?	?
Fish debris	Vagrant Predators	Nekto-Planktonic

Table 9

Percentages of Species of Each Feeding Type and Mode of Life in the Transitional Community

Feeding Types	Particulate	22.50%	
	Suspension	25.00%	
	Deposit	47.50%	
	Predator	5.00%	
Modes of Life	Epifaunal	60.00%	(20.83% are nekto-planktonic)
	Infaunal	40.00%	

Epifaunal forms again appear to be dominant. Removal of 20.83% (nekto-planktonic forms) leaves 39.17% of the species epifaunal as compared to 40.00% infaunal. There is much less difference between these two categories in this community than in the Glabrocingulum Community. The difference here is 0.83% and in the nearer shore community it is 9.37% in favor of the infaunal species. Greater distance from shore appears to be reflected by an increase in the percent of epifaunal species as is expected. The percent of infaunal species in both communities is essentially the same (40.00% of Transitional and 39.47% Glabrocingulum). The Transitional Community is actually characterized by epifaunal and infaunal deposit feeders reflecting slightly less influence from land-derived clastics.

Cleiothyridina Community

Four of the remaining six fossil assemblages are assigned to this community (G-815.1', G-816.0', E-835.0' and E-835.5'). The similarity between these four stations is not as great (numerically) as that of the thirteen stations which compose the Glabrocingulum and Transitional communities (fig. 10). Stations G-816.0' and E-835.5' are related at the 0.83 level, station G-815.1' correlates with these two at the 0.81 level and station E-835.0' to the three at the 0.72 level.

Stratigraphically, this community is in the middle claystone unit and the lowest part of the upper claystone. It is above (younger than) the two previously discussed communities. This community has the highest diversity index of the four, 9.84 (table 10) which supports the sequence of depths proposed (R. G. Johnson, 1969, personal communication). There are 45 species represented by 37,356 individuals.

The depositional environment of the middle claystone was interpreted as a more open marine area such as an open, unrestricted bay or prodelta area. This interpretation places the Cleiothyridina Community in what is often referred to as a "normal" marine environment. The other three communities are nearer shore and influenced more by land-derived sediments and other factors which produce a more highly variable environment. Environmental conditions are also variable for the Cleiothyridina Community but the amplitudes of the variations are lower.

Material composing the substratum is again clay-sized but calcareous and with a darker color. The color may reflect the absence of severe oxidizing conditions of the other environments. Depths were probably slightly greater than those of the inshore areas. This might mean that conditions on the bottom were more stable. Turbulence was probably moderate to high but less than in the two previous communities.

Turbidity would be controlled by depth, size of the waves and nature of the currents. Since this community is interpreted as being in a more open marine area there could have been a considerable amount of energy available. However, there are abundant small individuals of the community members present in the sediments. Available energy also affects the turbidity. High energy would increase it by stirring up the soft, shallow mud bottom. All of these factors will vary greatly on an hourly, daily, monthly and/or yearly basis.

Salinity was probably the most constant of all the environmental factors. Salinity effects by surface water runoff would be far less than in the inshore areas.

Biotic Elements

Indigenous Forms. Some representative fossils of this community are illustrated on Plate IV (figs. 4, 5, 7, 10, 12, 19, 22, 23, 27 and 29). The most abundant genus in this community, excluding foraminifers, is the brachiopod *Cleiothyridina orbicularis* (2.99%, table 10), for which the community was named. Pseudozygopleurid snails are more abundant (9.96%) but since they were not separated into genera they were not considered when a name was chosen. The nature and composition of the *Cleiothyridina* Community is represented in Table 10 (notations are as defined in Appendix III). All the major phyla have increased, compared to the Transitional Community, except the coelenterates, molluscans and echinoderms. The same gastropod genera are present with one new form, *Soleniscus* sp., but the pelecypods are represented by only four taxa. Scaphopods and cephalopods are the same, hence there is an overall decrease in molluscan diversity.

Table 10

Nature and Composition of Cleiothyridina Community

Taxonomic Entity	Avg. No. of Indiv.	Percent of Indiv.	Percent Artic.	Percent BV or LV	Percent Broken
Ammobaculites sp.	12768.0	34.2	-	-	-
Ammodiscus sp.	7494.0	20.1	-	-	-
Bathysiphon sp.	1040.0	2.8	-	-	-
Earlandinita sp.	1344.0	3.6	-	-	-
Endothyranella sp.	864.0	2.3	-	-	-
Fusulina sp.	176.5	0.5	-	-	-
Globovalvulina sp.	32.0	0.09	-	-	-
Lituotuba sp.	1072.0	2.9	-	-	-
Reophax sp.	704.0	1.9	-	-	-
Tolypammina sp.	393.0	1.05	-	-	-
Lophophyllum cf. L. profundum	0.7	0.002	-	-	*
Ramose Bryozoa	230.0	0.6	-	-	100.0
Fenestrate Bryozoa	128.0	0.3	-	-	100.0
Fistuliporids	5.0	0.01	-	-	100.0
Lindstroemella cf. L. patula	25.0	0.07	100.0		40.7
Cancrinella sp.	0.5	0.001	*	*	*
Chonetinella cf. C. flemingi	1.0	0.003	*	*	*
Cleiothyridina orbicularis**	1118.0	2.99	75.0	50.1	57.4
Crurithyris planoconvexa**	637.0	1.7	55.5	44.6	51.2
Derbyia crassa	3.7	0.01	85.7	100.0	100.0
Mesolobus decipiens**	296.0	0.8	49.7	42.9	57.5
Mesolobus euampygus**	233.0	0.6	43.9	68.9	37.7
Marginiferid fragments	3.0#				
Other Productoid fragments	605.3#				
Rhipidomella sp.	0.3	<0.001	*	*	*
Plagioglypta sp.**	421.0	1.1	-	-	100.0
Anthraconeilo taffiana**	83.0	0.2	96.5	25.0	45.9
Nuculopsis (Palaeonucula) anodontoides**	26.0	0.07	100.0		0.0
Nuculopsis (Palaeonucula) wewokana**	529.0	1.4	100.0		21.7
Polidevica bellistriata**	64.7	0.2	85.7	100.0	66.7

Table 10--(Continued)

Taxonomic Entity	Avg. No. of Indiv.	Percent of Indiv.	Percent Artic.	Percent BV or LV	Percent Broken
Straparolus (Amphiscapha) catilloides	112.0	0.3	-	-	0.0
Bellerophon (B.) cf. B. (B.) crassus	16.5	0.04	-	-	50.0
Euphemites carbonarius**	330.0	0.9	-	-	60.0
Girtyspira sp.	80.0	0.2	-	-	0.0
Glabrocingulum (Ananias) grayvillensis**	618.0	1.7	-	-	55.8
Ianthinopsis sp.**	454.0	1.2	-	-	0.0
Meekospira peracuta**	470.0	1.3	-	-	87.0
Pseudozygopleurids**	3723.0	9.96	-	-	21.0
Soleniscus sp.**	77.5	0.21	-	-	50.0
Trepospira depressa**	825.0	2.2	-	-	75.0
Pseudorthoceras sp.**	23.0	0.06	-	-	100.0
Gastrioceras sp.**	120.0	0.3	-	-	0.0
Ditomopyge sp. fragments	37.5#				
Other Trilobite fragments	402.0#				
Amphissites sp.	35.6	0.09	75.0	?	33.3
Bairdia sp.	520.0	1.4	83.9	?	0.0
Cavellina sp.	24.9	0.07	100.0		0.0
Healdia sp.	178.0	0.5	100.0		0.0
Hollinella sp.	48.0	0.1	93.2	?	0.0
Moorites sp.	10.7	0.03	100.0		0.0
Crinoid debris	1549.0#				100.0
Echinoid debris	2175.0#				100.0
Holothurian debris	924.0#				100.0
Ophiuroid &/or Asteroid debris	1861.0#				100.0
Conodonts	600.0#				
Fish debris	64.0#				
Faecal pellets	1240.0#				

N = 45; n = 37356; DI = 9.84

Brachiopods are the dominant element in terms of diversity, if the number of taxa (11) are compared to the number of genera in each of the molluscan classes (scaphopods-1, pelecypods-4, gastropods-10 and cephalopods-2). Gastropods and foraminifers are second with ten genera each and the arthropods are third with eight taxa.

New brachiopods are Mesolobus decipiens, Derbyia crassa, Chonetinella cf. C. flemingi, Cancrinella sp. and Rhipidomella sp. in order of their abundance. Mesolobus decipiens was present in the Glabrocingulum Community but contributed only 0.14% of the total individuals in that community. In this one it is 0.8% of the total individuals, an increase of almost 0.7%. There are decreases in these percentages for Lindstroemella, Crurithyris and Mesolobus euampygus as compared to the Transitional Community. Lindstroemella, an inarticulate sessile benthos (orbiculoid) appears to have been more characteristic of nearer shore environments (Hattin, 1957, p. 86; McCrone, 1963, p. 55-56 and Lane, 1964, p. 17). Perhaps Crurithyris and Mesolobus euampygus also preferred the shallower nearshore waters. There are also fragmented specimens of marginiferids and other productoids. The inarticulate, Lindstroemella, often occurs as an epizoan on the brachial valve of the chonetoids.

Additional bryozoans are represented by fragments of the fenestrates and the encrusting fistuliporids. These latter forms occur encrusting crinoid stems, brachiopods, corals and some gastropods. The fenestrates are not represented by large frond fragments but rather, by small pieces indicating considerable breakage.

Fusulinids (<u>Fusulina</u> sp.) occur in this community, and in none of the other three, as an indigenous member. The specimens found in this community exhibit signs suggesting transportation in that, the tests are pitted and slightly corroded. This might suggest that they were more characteristic of areas farther offshore. Ross (1965, p. 1156) in talking about the paleoecology of Late Pennsylvanian fusulinids states:

> Shallow water facies, having considerable evidence of wave and current motion, appear to have local abundances of several species that are generally large, thickly fusiform in shape, and have thick walls (Ross, 1961). Less agitated environments in the Gaptank Formation have fewer species and rarer individuals.

<u>Fusulina</u> is not a large fusulinid but it does have a more or less thickly fusiform shape. It is large compared to the other Desmoinesian fusulinids (Alexander, 1954). The few individuals that occur would be expected in the environment postulated for this community, in light of Ross's comments (i.e., less agitation). The most plausible explanation is that, while some few individuals were part of this community, the majority of Desmoinesian fusulinids preferred more offshore areas (more marine, farther from land) of greater agitation.

The most abundant organisms in this community are the foraminifers, <u>Ammobaculites</u> sp. (34.2%) and <u>Ammodiscus</u> sp. (20.1%). <u>Tolypammina</u>, an encrusting form, is common on brachiopod shells as an epizoan.

In addition to the ostracodes and trilobite fragments of the Transitional Community, there are other trilobite fragments which can be assigned to <u>Ditomopyge</u> cf. <u>D</u>. <u>parvulus</u>. These fragments are the pygidia and cephalons (lacking the free cheeks).

Other fragmented and/or disassociated skeletal elements represent crinoids, echinoids, holothurians, ophiuroids, asteroids and fish. While some of these were, in all probability transported into the environment, the majority lived in this community. Evidence for this interpretation is obtained from the nature of preservation, diversity of the skeletal elements and their abundances in the assemblages.

Transported Forms. Criteria used previously have been applied here to differentiate between indigenous and non-indigenous fossils. Organisms that occur in the fossil assemblages of this community, but excluded from Table 10, are listed in Table 11. Averages of the total number of individuals of each taxonomic entity in the four fossil

Table 11

Transported Biotic Elements in the *Cleiothyridina* Community

Taxonomic Entity	Average Number of Individuals
Prismopora sp.	0.50
Lingula cf. *L. carbonaria*	32.50
Composita cf. *C. subtilita*	0.25
Hustedia cf. *H. mormoni*	0.25
Nuculopsis girtyi	0.25
Paleyoldia glabra	0.25
Knightites (*Cymatospira*) *montfortianum*	0.25
Phymatopleura nodosus	1.00

assemblages provides an indication of the contribution of each transported biotic element. *Prismopora*, *Composita* and *Hustedia* are probably from a community farther offshore than this one, if so they have been transported shoreward. Only one of these, Hustedia, has been found in assemblages representing other communities and it was considered a transported element in that community (Transitional). The other transported elements are characteristic (members) of nearer shore communities, with the exception of Phymatopleura.

It is interesting to note that as one proceeds towards areas interpreted as more offshore, the number of transported biotic elements decreases. In the Glabrocingulum Community there were 20 such elements, in the Transitional Community 11 and in this community only 8. A sea bottom with a more or less constant slope seaward with "average" waves and currents operating in the overlying water mass could explain these observations. Approaching shore the waves will have more and more effect on the bottom sediments and benthic communities. This would transport members (fragments of members) of the offshore benthic communities into the communities of nearer shore waters. The undertow, as the water recedes from the beach, and rip currents would then carry certain nearshore organisms seaward. In the process, of course, the transported shells would be broken, pitted and corroded, reducing most of them to unidentifiable fine shell debris. Storms were probably the most common agent in this regard (R. G. Johnson, 1969, personal communication).

Taphonomic (Post-Mortem) Effects. Biotic elements of this community which have been severely crushed are Gastrioceras, Cleiothyridina and the productoid brachiopods. No specimens of Gastrioceras were broken but virtually every individual was crushed. Individuals of Cleiothyridina were crushed in the same way that they were in the assemblages of the Transitional Community. Crushing reduced most of the productids to partial specimens and fragments. Other biconvex forms were also slightly crushed, Crurithyris, Mesolobus, Derbyia, Anthraconeilo and Polidevica. Although altered in this manner all of them were identifiable. Sizing procedure was hindered very little, those too badly distorted were not used in the size-frequency distributions.

Size-frequence distributions of the members of this community have been affected by solution, selective predation, transportation and/or other effects. Certain size classes of individuals are reduced or completely missing (figs. 19-C, 19-D, 20-B, 20-D, 21-C and 21-F). Used with the other criteria, discussed previously, it was possible to determine the nature of each fossil population, even though the distributions were altered.

Plagioglypta sp. and Pseudorthoceras sp. are preserved only as broken fragments. Methods by which this could have occurred have already been discussed.

Corals did not occur in sufficient numbers to permit calculation of the percentage of broken individuals, but all the specimens found were broken. All of the bryozoans were fragments, that is, they are represented by broken segments of colonies. Some of this breakage was, no doubt, due to physical agents (waves and currents). But part of it could be the result of scavenging and/or predation. It has already been pointed out that in present seas fish nibble on calcareous organisms, notably corals and calcareous algae (Wells, 1957, p. 613).

In this community, as in the two previous ones, the epifaunal organisms have higher percentages of broken individuals than do the

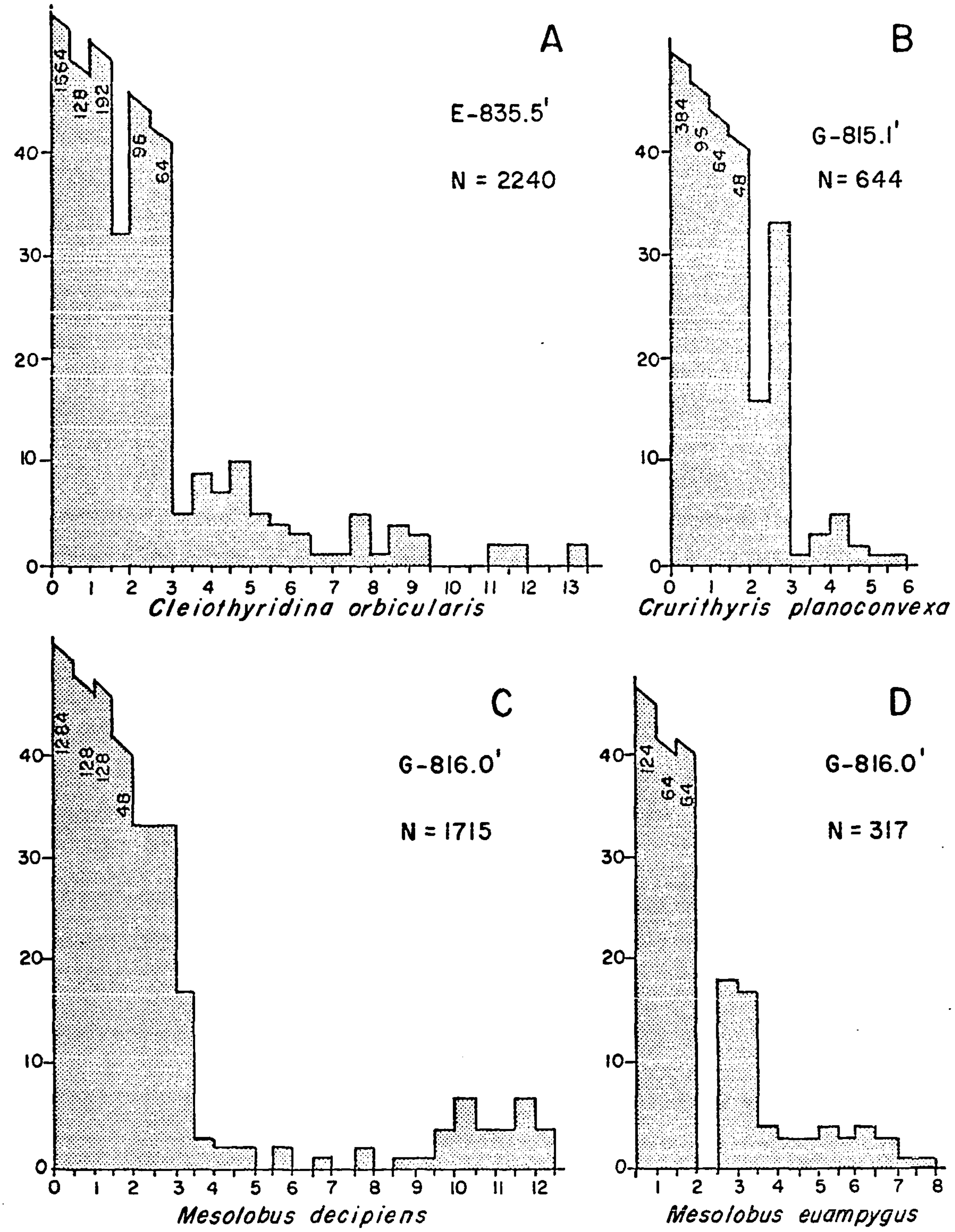


Figure 19. Size-frequency distributions of brachiopods from the <u>Cleiothyridina</u> Community (ordinate is frequency, numbers of individuals; abscissa is size in millimeters; letter prefixed numbers refer to collecting stations; N = total number of individuals in the distribution).

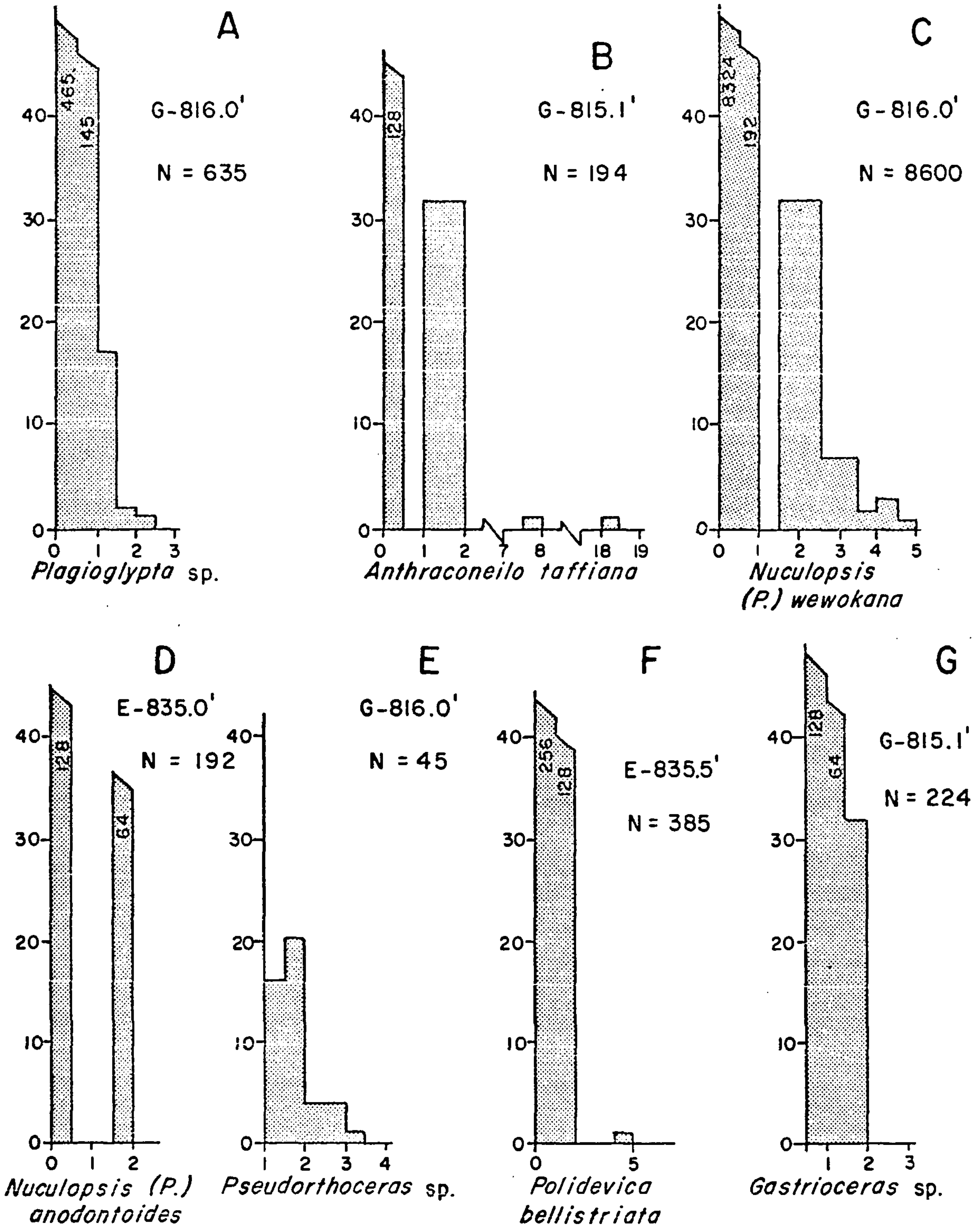


Figure 20. Size-frequency distributions of scaphopods, pelecypods and cephalopods from the Cleiothyridina Community (ordinate is frequency, numbers of individuals; abscissa is size in millimeters; letter prefixed numbers refer to collecting stations; N = total number of individuals in the distribution).

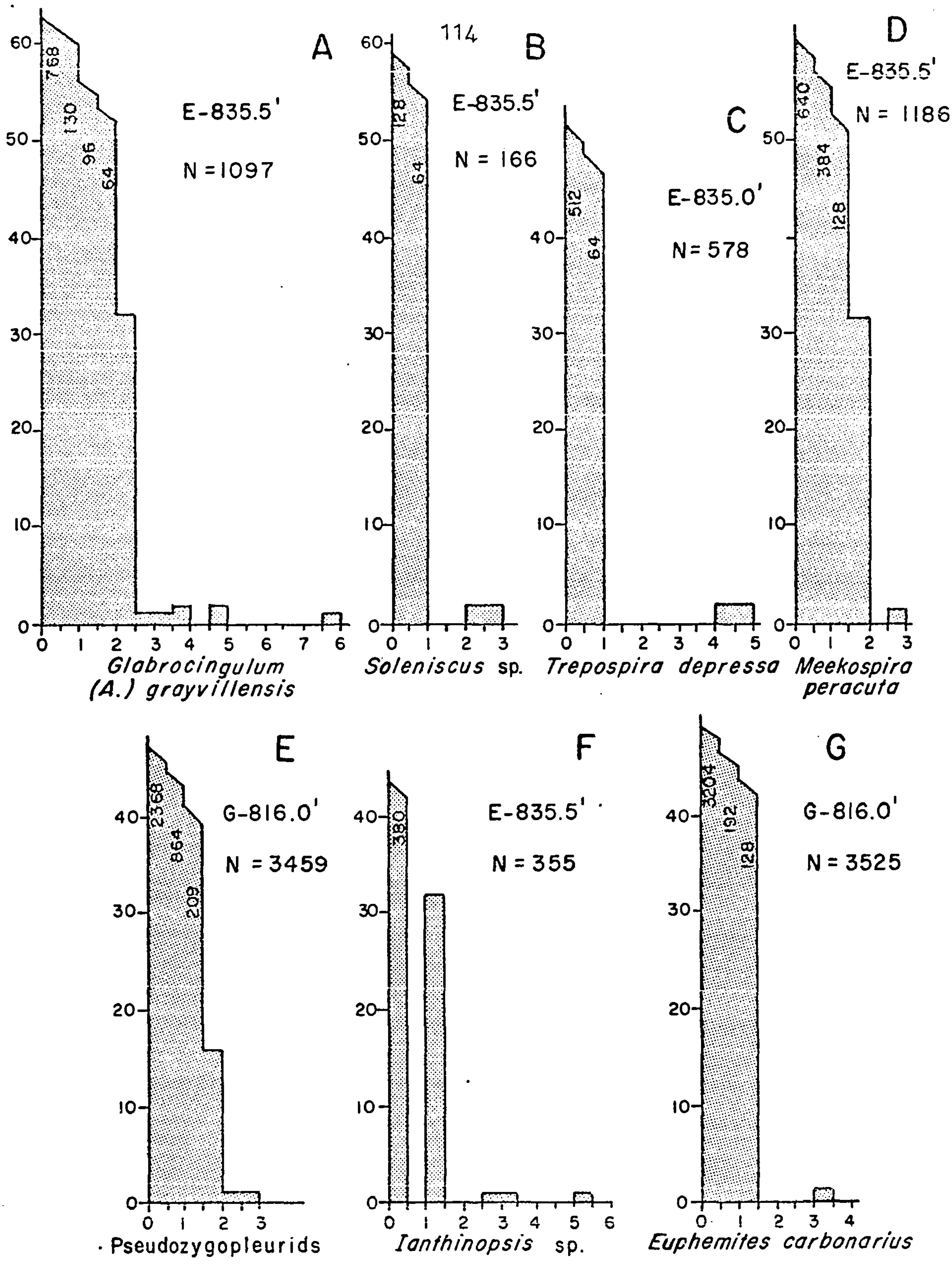


Figure 21. Size-frequency distributions of gastropods from the Cleiothyridina Community (ordinate is frequency, numbers of individuals; abscissa is size in millimeters; letter prefixed numbers refer to collecting stations; N = total number of individuals in the distribution).

infaunal ones. The epifaunal forms, with the percentage of each that was broken, are: Derbyia crassa - 100.0%, Cleiothyridina orbicularis - 57.4%, Crurithyris planoconvexa - 51.2%, Euphemites carbonarius - 60.0%, Meekospira peracuta - 87.0% and Trepospira depressa - 75.0%. Anthraconeilo taffiana - 45.9%, Nuculopsis (P.) anodontoides - 0.0% and Nuculopsis (P.) wewokana - 21.7% are broken infaunal forms. Predaceous organisms, cephalopods, asteroids and fish within the community are probably responsible for some of this breakage.

Community Structure

To provide an interpretation of the feeding types and modes of life of every preserved organism within the Cleiothyridina Community, Table 12 has been prepared. The biotic elements represented by fragmented and/or disassociated remains are not included in the calculations (table 13 and fig. 22-C) discussed later in this section. Definitions and usage of the feeding categories and modes of life are discussed in conjunction with the Glabrocingulum Community.

The mode of life and feeding methods of the 45 species in this community are consolidated into percentages and presented in Table 13. These percentages are in terms of species, just as they are for the other communities. Figure 22-C is a graphic representation of this same information. From these data it is obvious that the Cleiothyridina Community is different from the two previously considered communities. Little change is noted in the percentages of particulate feeders and predators. The values are about the same for all three of them. If individuals, rather than species, had been used the particulate feeders would be the most

Table 12

Feeding Type and Mode of Life of the Members of the Cleiothyridina Community

Taxonomic Entity	Feeding Type	Mode of Life
Ammobaculites sp.	Particulate Matter	Epifaunal (Benthic)
Ammodiscus sp.	Particulate Matter	Epifaunal (Benthic)
Bathysiphon sp.	Particulate Matter	Epifaunal (Benthic)
Earlandinita sp.	Particulate Matter	Epifaunal (Benthic)
Endothyranella sp.	Particulate Matter	Epifaunal (Benthic)
Fusulina sp.	Particulate Matter	Epifaunal (Benthic)
Globovalvulina sp.	Particulate Matter	Epifaunal (Benthic)
Lituotuba sp.	Particulate Matter	Epifaunal (Benthic)
Reophax sp.	Particulate Matter	Epifaunal (Benthic)
Tolypammina sp.	Particulate Matter	Epizoan (Sessile)
Lophophyllum cf. L. profundum	Cemented Suspension	Epifaunal (Sessile
Ramose Bryozoa	Cemented Suspension	Epifaunal (Sessile)
Fenestrate Bryozoa	Cemented Suspension	Epifaunal (Sessile)
Fistuliporids	Cemented Suspension	Epifaunal (Sessile)
Lindstroemella cf. L. patula	Cemented Suspension	Epifaunal (Sessile) some as Epizoans
Cancrinella sp.	Spiny Suspension	Epifaunal
Chonetinella cf. C. flemingi	Spiny Suspension	Epifaunal
Cleiothyridina orbicularis**	Pedunculate Suspension	Epifaunal (Sessile)
Crurithyris planoconvexa**	Pedunculate Suspension	Epifaunal (Sessile)
Derbyia crassa	Cemented Suspension	Epifaunal (Sessile)
Mesolobus decipiens**	Spiny Suspension	Epifaunal
Mesolobus euampygus**	Spiny Suspension	Epifaunal
Marginiferid fragments	Spiny Suspension	Epifaunal
Other Productoids fragments	Spiny Suspension	Epifaunal
Rhipidomella sp.	Pedunculate Suspension	Epifaunal (Sessile)
Plagioglypta sp.**	Bottom-Dwelling Deposit & Scav.	Infaunal
Anthraconeilo taffiana**	Labial-palp Deposit	Infaunal
Nuculopsis (Palaeonucula) anodontoides**	Labial-palp Deposit	Infaunal
Nuculopsis (Palaeonucula) wewokana**	Labial-palp Deposit	Infaunal
Polidevica bellistriata**	Labial-palp Deposit	Infaunal

Table 12--(Continued)

Taxonomic Entity	Feeding Type	Mode of Life
Straparolus (Amphiscapha) catilloides	Vagrant Browsers & Deposit	Epifaunal
Bellerophon (B.) cf. B. (B.) crassus	Vagrant Browsers & Deposit	Epifaunal
Euphemites carbonarius**	Vagrant Browsers & Deposit	Epifaunal
Girtyspira sp.	Vagrant Browsers & Deposit	Epifaunal
Glabrocingulum (Ananias) grayvillensis**	Vagrant Browsers & Deposit	Epifaunal
Ianthinopsis sp.**	Vagrant Browsers & Deposit	Epifaunal
Meekospira peracuta**	Vagrant Browsers & Deposit	Epifaunal
Pseudozygopleurids**	Vagrant Browsers & Deposit	Epifaunal
Soleniscus sp.**	Vagrant Browsers & Deposit	Epifaunal
Trepospira depressa**	Vagrant Browsers & Deposit	Epifaunal
Pseudorthoceras sp.**	Vagrant Predators	Nekto-Planktonic
Gastrioceras sp.**	Vagrant Predators	Nekto-Planktonic
Ditomopyge sp. fragments	Bottom-Dwelling Deposit & Scav.	Epi-Infaunal
Other Trilobite fragments	Bottom-Dwelling Deposit & Scav.	Epi-Infaunal
Amphissites sp.	Bottom-Dwelling Deposit & Scav.	Nekto-Planktonic to Infaunal
Bairdia sp.	Bottom-Dwelling Deposit & Scav.	Nekto-Planktonic to Infaunal
Cavellina sp.	Bottom-Dwelling Deposit & Scav.	Nekto-Planktonic to Infaunal
Healdia sp.	Bottom-Dwelling Deposit & Scav.	Nekto-Planktonic to Infaunal
Hollinella sp.	Bottom-Dwelling Deposit & Scav.	Nekto-Planktonic to Infaunal
Moorites sp.	Bottom-Dwelling Deposit & Scav.	Nekto-Planktonic to Infaunal
Crinoid debris	Rooted Suspension	Epifaunal (Sessile)
Echinoid debris	Vagrant Browsers, Deposit & Scav.	Epifaunal to Infaunal

Table 12--(Continued)

Taxonomic Entity	Feeding Type	Mode of Life
Holothurian debris	Bottom-Dwelling Deposit & Scav.	Infaunal
Ophiuroid &/or Asteroid debris	Vagrant Browsers, Deposit & Pred.	Epifaunal
Conodonts	?	?
Fish debris	Vagrant Predators	Nekto-Planktonic

Table 13

Percentages of Species of Each Feeding Type and Mode of Life in the *Cleiothyridina* Community

Feeding Type	Particulate	22.22%	
	Suspension	33.33%	
	Deposit	40.00%	
	Predator	4.40%	
Mode of Life	Epifaunal	71.11%	(15.63% are nekto-planktonic)
	Infaunal	28.89%	

abundant, since two genera (Ammobaculites and Ammodiscus) account for 54.3% of the total individuals in this community.

Sizeable changes are noted in the suspension and deposit feeders. Forty percent of the species in this community are deposit feeders, compared to 33.33% suspension feeders. The difference between these two types is less (6.67%) than it is for the other two (18.79% Glabrocingulum and 22.50% Transitional) communities. This is due to the increase in the brachiopods (suspension feeders) and a decrease in the nuculoid pelecypods (deposit feeders). Environmentally this community is farthest from shore, hence there is less land-derived detritus affecting its organisms. This would provide an advantage to suspension feeding organisms. Waters clouded by abundant suspended inorganic material could clog the feeding organs, rendering them ineffective, thus the organism would not survive. While the deposit feeders are still dominant, conditions appear to be shifting towards those more favorable for suspension feeders.

There are few Paleozoic marine organisms which are infaunal and feed on suspended material (Stanley, 1968, concerning pelecypods) and there is no evidence for such forms in this community (Lingula and polychaetes). If the suspension feeders increase and deposit feeders decrease, as noted above, this should reflect an increase in epifaunal organisms and a decrease in infaunal ones. In terms of species this is clearly the case in the Cleiothyridina Community (Figure 22-C). Epifaunal forms constitute 78.95% of the species and even with the removal of the nekto-planktonic species (13.33%) there are still 65.62% of the species that are epifaunal benthos (sessile or vagrant). Infaunal species account for only 21.05% of the 45 total. In the Transitional Community 39.17% of the epifaunal species are benthos and in the Glabrocingulum Community only 30.10% fit this category. The Cleiothyridina Community is much more of an epifaunal association than either of the other two. It is characterized by epifaunal deposit and suspension feeders which supports the environmental interpretation that this community is the farthest from shore.

Mesolobus Community

Fossil assemblages at G-824.0' and G-825.0' are related at the 0.67 level (fig. 10) to form this community. This is the level at which the other three communities are correlated. Therefore, the similarity between these two assemblages is less than the similarity found between the other 17 assemblages and three subsequent communities.

This community is, stratigraphically, the highest of the four benthic communities defined in this study. The two stations in Section G are the only place that this community was encountered, however, it is probably represented in the middle and upper parts of bed 25 at Section E as well.

A diversity index of 4.33 (table 14) was obtained from 24,511 specimens of 19 species. All three values (number of specimens, number of species and index) are the lowest obtained for any of the four communities.

In terms of relative age, this is the youngest community and occurs in the upper part of the lower third of the upper claystone unit. Environmentally this unit has been interpreted as representing a return to nearer shore conditions. Presence of more sand and silt size quartz in this unit, as well as its other lithologic and paleontologic characters, resulted in placing it nearshore in an area greatly influenced by land-derived detritus. The lower part of this unit was probably farther offshore (more marine) than the upper portions, but nearer shore (less marine) than the units containing the Cleiothyridina Community. Environmental placement of the Mesolobus Community would be in a marine area that received terrigeneous material, such as a restricted bay in an area of deltaic sedimentation. It is, environmentally, similar to the Glabrocingulum and Transitional communities but probably received much more dilution from freshwater runoff and more debris from the nearby land areas. The fact that this claystone underlies sandstones of supposed deltaic origin (Weaver, 1954) makes such an environmental placement plausible.

While clay-size material still dominates the substrate of this community, fine sand size material also contributed conspicuous amounts. Water depths were probably shallower than those of the Cleiothyridina Community. This is supported by a statement quoted previously from Elias (1962, p. 110) that when found alone and in great numbers the chonetids (Mesolobus is a chonetid) probably represent shallower water than normal for articulate brachiopods. Shallow water with a mud to silty, sandy bottom would cause turbidity to be moderate. Energy may have been moderate though numerous small individuals of the chonetids are present in the assemblages. Salinity would probably be less than "normal" due to dilution by freshwater runoff. Brackish conditions probably prevailed part of the time.

Biotic Elements

Indigenous Forms. Those organisms considered members of this community are listed in Table 14 (notations are as defined in Appendix III) along with the information on numbers and percentages as given for the other communities. Excluding the foraminifers, the dominant biotic element is the genus Mesolobus (2.0%) which provides the community name. There are two species of this genus, decipiens and euampygus, with the former being nearly six times as abundant as the latter. M. decipiens is the most abundant of the two species (1.7%) with only 0.3% M. euampygus. This is the highest percentage of M. decipiens in the three communities of which it is a member. Concerning M. euampygus, this percentage is greater than the one in the Glabrocingulum Community but less than the values for the Transitional and Cleiothyridina communities.

Lingula cf. L. carbonaria is again present as is the cosmopolitan Crurithyris planoconvexa. Lingula occurs in the Glabrocingulum Community, contributing 1.3% to the total individuals. In this community it contributes only 0.3%. Crurithyris, though represented in all four communities, has the lowest value in this one, only 0.2%. Productids are represented by broken fragments (a large number of spines), some of which were probably indigenous. Strophalosid brachiopods occur attached to crinoid columnals and may be immature individuals of other productid genera.

The orbiculoid, Lindstroemella cf. L. patula, is particularly interesting in this community. It occurs occasionally as an epizoan on brachiopod shells, especially along the anterior commissure of the

Table 14

Nature and Composition of Mesolobus Community

Taxonomic Entity	Avg. No. of Indiv.	Percent of Indiv.	Percent Artic.	Percent BV or LV	Percent Broken
Ammobaculites sp.	10816.0	44.1	-	-	-
Ammodiscus sp.	3008.0	12.3	-	-	-
Bathysiphon sp.	6592.0	26.9	-	-	-
Earlandinita sp.	1536.0	6.3	-	-	-
Lituotuba sp.	320.0	1.3	-	-	-
Reophax sp.	1264.0	5.2	-	-	-
Tolypammina sp.	22.5	0.09	-	-	-
Lingula cf. L. carbonaria	64.0	0.3	100.0		0.0
Lindstroemella cf. L. patula	6.0	0.02	*	*	*
Crurithyris planoconvexa	50.0	0.2	20.0	60.0	100.0
Mesolobus decipiens**	409.0	1.7	70.3	51.2	80.5
Mesolobus euampygus**	64.5	0.3	57.1	42.9	55.7
Productoid fragments	3250.0#				
Strophalosids	1.5	0.006	*	*	*
Plagioglypta sp.	16.0	0.07	-	-	100.0
Euphemites carbonarius	32.0	0.12	-	-	0.0
Pseudozygopleurids	96.0	0.39	-	-	0.0
Pseudorthoceras sp.	16.0	0.07	-	-	100.0
Bairdia sp.	176.0	0.7	100.0		0.0
Healdia sp.	21.3	0.09	100.0		0.0
Crinoid debris	6310.0#				100.0
Echinoid debris	1200.0#				100.0
Holothurian debris	160.0#				100.0
Ophiuroid and/or Asteroid debris	731.0#				100.0

N = 19; n = 24511; DI = 4.33

brachial valve of the chonetids (pl. IV, fig. 3), in this and the other communities. There are some facts which tend to support the idea that these inarticulates were attached during the articulate's life. Lindstroemellids always occur on the brachial valve of the mesolobids and this is not the stable position of these valves after death. Chonetids have a concavo-convex shell form with the brachial valve gently concave. Hydrodynamic stability of single valves of bivalves has been shown to be convex side up (Menard & Boucot, 1951, p. 148 and Emery, 1968). Therefore, after death, assemblages of the articulated mesolobids would tend to be oriented brachial valve downward as a result of wave and/or current action and would not be available for settlement of the orbiculoid larvae. Although not a high energy environment, sufficient energy was probably available to invert (pedicle valve up) the individuals after death.

Concerning the life position (Lebenstellung) of chonetids Boger (1968, p. 127-129) suggests, that in terms of the statics of a chonetid shell, life position was with the brachial valve up. The organism rested on the pedicle valve at a point corresponding to the shell's center of gravity. This center of gravity was near the posterior margin due to the counter balancing effect of the spines along the hinge line.

The same relationship between orbiculoids and chonetids has been observed by the author in specimens of Chonetes from the Francis Formation of Oklahoma. Ivanova (1949, fig. 17; 1962, fig. 15) illustrates some articulate brachiopods with inarticulates attached to one or both valves.

The fact that the mesolobid shells provide a stable platform for the orbiculoid spat is adequate to explain their presence. However, action of the ciliated lophophore of Mesolobus during periods of feeding would provide favorable water currents for the epizoan. Some type of commensal or symbiotic relationship probably existed between these organisms (Dale, 1957). There is no a priori reason to believe the relationship could be parasitic with Mesolobus the host.

Foraminifers are basically arenaceous with Ammobaculites, Bathysiphon and Ammodiscus contributing 44.1, 26.9 and 12.3 % of the average number of total individuals. The more offshore ("normal" marine) forms, Endothyranella, Globovalvulina and Fusulina are absent. Tolypammina occurs encrusting bivalves as in the other communities.

The pseudozygopleurid snails are the most abundant molluscans (0.39%). There are no pelecypods and one additional snail, Euphemites carbonarius. The orthocone, Pseudorthoceras, and the scaphopod Plagioglypta make a total of four molluscan forms.

Arthropods are represented by two ostracode genera (Bairdia and Healdia) with smooth carapaces. Fragmented and/or disassociated remains of echinoderms include crinoids, echinoids, holothurians, asteroids and ophiuroids. As in the other communities, some of the echinoderm debris could represent transported material. Probably more of it is transported into this community because of the low diversity of types of skeletal elements, particularly of the echinoids and crinoids. Remains of these two types of echinoderms are represented almost exclusively by spines and columnals respectively. Certainly some individuals of both groups lived in the community but perhaps not as many as the average number of fragments might suggest.

Transported Forms. Crinoids, echinoids and productid fragments were excluded from this section because some of these are interpreted as belonging to the Mesolobus Community and there is no way to adequately separate indigenous from non-indigenous forms. Those taxonomic entities of Table 15 are considered transported on the basis of previously discussed criteria. Cleiothyridina may have been carried in from more offshore areas (more "normal" marine environment). The pelecypod could have come from the main area of a bay or other favorable environment where communities similar to the Glabrocingulum and Transitional types occurred.

Table 15

Transported Biotic Elements in the Mesolobus Community

Taxonomic Entity	Average Number of Individuals
Cleiothyridina orbicularis	8.0
Nuculopsis (Palaeonucula) wewokana	0.5

Taphonomic (Post-Mortem) Effects. Forms most affected by these effects are Crurithyris, Plagioglypta and Pseudorthoceras. These forms are broken; crushed individuals are scarce compared to the other communities. An occasional brachiopod, particularly Crurithyris, will be crushed but very few of the other groups exhibit this effect.

Post-mortem effects have removed all traces of any soft-bodied organisms and removed or reduced certain size classes of individuals. Figures 18-D and 18-E are size-frequency distributions of the only two community members with complete enough records to permit preparation of these distributions. It is obvious that certain sizes of individuals are completely missing or reduced in numbers. Such alteration could be due to predators (selectively eating certain sizes of individuals and fragmenting the shells beyond recognition), solution, transportation away from the Lebensraum or a combination of these three. These alterations could also be due to low mortality and/or recruitment failure of the chonetids. However, these latter two causes are not post-mortem effects.

All specimens of the three above mentioned genera are broken. Reasons for this in Plagioglypta and Pseudorthoceras have been previously discussed. Over 50% of both species of Mesolobus are broken as well as all specimens of Crurithyris. Percentage of articulation is higher for both species of Mesolobus than it is for Crurithyris. It is possible that most of the breakage of Crurithyris is due to predators (asteroids?).

Pelecypods are considered the normal prey of asteroids in present seas (Carter, 1968), but in the Mesolobus Community there is no evidence of pelecypods, not even faecal pellets. If the asteroids were present, as suggested by preserved skeletal elements, perhaps they preyed on the small spiriferid brachiopod Crurithyris. Since Crurithyris was epifaunal and readily available to any epifaunal asteroids this is plausible. This also appears to be supported by a high percentage of crurithyrid brachial valves (60.0%) permitting the implication that the pedicle valves were broken and subsequently destroyed. Some breakage of the mesolobids may have also been due to this method. The remainder of the broken forms, of both genera, were broken by other agents, transportation and/or scavengers.

Community Structure

Table 16 indicates the feeding type and mode of life of each preserved member of the Mesolobus Community. It is apparent that there are few infaunal members in this community. The community appears to be dominated by suspension feeders. Table 17 provides a closer look at this situation. As in previous tables of this nature, the fragmented and/or disassociated organisms have been excluded. Percentages in this table are in terms of species (the 19 used in calculating the diversity index).

These same data are illustrated graphically in Figure 22-D. It is immediately obvious that there is a great difference between this community and the other three (as suspected from table 16). The percentages of suspension and particulate feeders are the same. There are no additional genera of the particulate feeding foraminifers but reduction in other feeding groups (deposit feeders) is responsible for their apparent importance. Suspension feeders have increased slightly. In part, this is also due to the absence of other feeding types, but there are also new suspension feeders. Deposit feeders have decreased drastically from percentages in the forties to the low twenties. There were no pelecypods in this community and the molluscans are represented by only four taxa, one of which is a predator. The absence of deposit

Table 16

Feeding Type and Mode of Life of the Members of the Mesolobus Community

Taxonomic Entity	Feeding Type	Mode of Life
Ammobaculites sp.	Particulate Matter	Epifaunal (Benthic)
Ammodiscus sp.	Particulate Matter	Epifaunal (Benthic)
Bathysiphon sp.	Particulate Matter	Epifaunal (Benthic)
Earlandinita sp.	Particulate Matter	Epifaunal (Benthic)
Lituotuba sp.	Particulate Matter	Epifaunal (Benthic)
Reophax sp.	Particulate Matter	Epifaunal (Benthic)
Tolypammina sp.	Particulate Matter	Epizoan (Sessile)
Lingula cf. L. carbonaria	Burrow-Dwelling Suspension	Infaunal (Sessile)
Lindstroemella cf. L. patula	Cemented Suspension	Epifaunal (Sessile) some Epizoan
Crurithyris planoconvexa	Pedunculate Suspension	Epifaunal (Sessile)
Mesolobus decipiens**	Spiny Suspension	Epifaunal
Mesolobus euampygus**	Spiny Suspension	Epifaunal
Productoid fragments	Spiny Suspension	Epifaunal
Strophalosids	Cemented Suspension	Epifaunal (Sessile)
Plagioglypta sp.	Bottom-Dwelling Deposit & Scav.	Infaunal
Euphemites carbonarius	Vagrant Browsers & Deposit	Epifaunal
Pseudozygopleurids	Vagrant Browsers & Deposit	Epifaunal
Pseudorthoceras sp.	Vagrant Predators	Nekto-Planktonic
Bairdia sp.	Bottom-Dwelling Deposit & Scav.	Nekto-Planktonic to Infaunal
Healdia sp.	Bottom-Dwelling Deposit & Scav.	Nekto-Planktonic to Infaunal
Crinoid debris	Rooted Suspension	Epifaunal (Sessile)
Echinoid debris	Vagrant Browsers, Deposit & Scav.	Epifaunal to Infaunal?
Holothurian debris	Bottom-Dwelling Deposit & Scav.	Infaunal
Ophiuroid and/or Asteroid debris	Vagrant Browsers, Deposit & Pred.	Epifaunal

feeding types (molluscans) is responsible for the higher percentages of particulate and suspension feeding species.

Table 17

Percentages of Species of Each Feeding Type and Mode of Life in the Mesolobus Community

Feeding Type	Particulate	36.84%	
	Suspension	36.84%	
	Deposit	21.05%	
	Predator	5.26%	
Mode of Life	Epifaunal	84.21%	(13.33% are nekto-planktonic)
	Infaunal	15.79%	

It is important to recall the nature of the substrate of this community to explain this difference in dominant feeding types. The bottom was basically mud but there were also considerable amounts of coarser material (sand size). From the work of Sanders (1956, Table IX) suspension feeders dominate communities where the percentage of clay and silt is low. At Station 4 in Long Island Sound, where the percentages of silt-clay is 5.4, suspension feeders compose 95.56% of the total community and deposit feeders only 4.44%. At this time there is no definite information available on the percentages of the various sizes of clastic particles in the Wewoka claystone. But, washed residues of the lithologies containing assemblages of the Mesolobus Community contain significant amounts of sand size material. Also the exact method Sanders (1956) used is not completely clear; it appears that his percentages are in terms of biomass (weight) and not species. Furthermore, soft-bodied organisms of the Mesolobus Community are not available as they are in present-day marine benthic communities. These factors permit the suggestion that suspension feeders were also more characteristic of substrates composed of coarse sediments in the ancient seas. Sanders (1956, p. 400) makes the following statement concerning the favorability of coarser sediments to suspension feeders:

> Since there is little net deposit of fine sediment in such environments, there are probably more pronounced bottom currents; hence more water and more food are made available to these organisms in a unit period of time.

Table 17 and Figure 22-D show that 84.21% of the 19 species of this community are epifaunal, removal of the 13.33% which are nektoplanktonic forms still leaves 70.88% epifaunal (sessile or vagrant) benthos. This is higher than any of the other three communities. Species interpreted as infaunal compose 15.79% of the community, which is the lowest of the four communities.

This community (Mesolobus) is much different from the other three. While it is placed in an environment very nearshore it is not structured like the other communities of nearshore environments. This is due to differences, though slight, in the nature of the substrate. The only infaunal element in this community which fed on suspended matter was the inarticulate brachiopod, Lingula. Epifaunal suspension feeding species are the characteristic biotic elements as opposed to infaunal deposit feeders of the other nearshore communities. This difference in community structure seems to be a reflection of slightly different physiochemical conditions as suggested by the nature of the substratum.

Substrate Mineralogy

The substratum was basically the same for three of the four communities, namely one of clay-sized material. Conspicuous amounts of sand size quartz in the samples containing representatives of the Mesolobus Community altered the substrate of this community. This implies that the various physical (currents, waves, turbidity, etc.) and chemical (salinity, nutrients, etc.) factors were different than those of the other communities. Structure of the mesolobid community also reflects these changes. The other communities are dominated by deposit feeders while the mesolobid community is characterized by suspension feeders.

Samples from 13 of the 19 collecting stations were submitted for X-ray diffraction analysis in hopes of determining differences in the mineralogy and hence chemistry of the substrate. Sedimented and powder slides were analyzed for each of the 13 samples. The results of these analyses are presented in Table 18.

It is apparent from this table that the mineralogy of the thirteen stations is essentially the same. If there were differences originally, diagenesis has eliminated them. The relative amounts of each of these minerals may be different which could reflect something as to the original mineralogy and chemistry of the substrate. Of course, the chemistry could be different even though the minerals are essentially the same. This is particularly true of trace elements which fill secondary sites in the crystal lattices of certain clay minerals.

Of the 13 samples submitted for X-ray diffraction analysis seven were selected for chemical analysis. These were powdered, mixed

Table 18

Mineralogy of 13 of the 19 Collecting Stations
Based on X-ray Diffraction Analysis

Station		Mineralogy
F-776.8'	Clay Minerals -	partially degraded illite, chlorite and kaolinite.
	Other Minerals -	quartz, feldspar, mica, and possibly some dolomite.
G-774.7'	Clay Minerals -	degraded illite, kaolinite and some chlorite.
	Other Minerals -	quartz, feldspar and mica.
H-773.0'	Clay Minerals -	degraded illite, kaolinite, and chlorite.
	Other Minerals -	quartz, feldspar, mica and possibly some dolomite?
C-796.5'	Clay Minerals -	partially degraded illite, chlorite and kaolinite.
	Other Minerals -	quartz, feldspar, mica and possibly dolomite.
E-793.0'	Clay Minerals -	partially degraded illite, chlorite and kaolinite.
	Other Minerals -	quartz, feldspar, mica and possibly dolomite.
F-781.7'	Clay Minerals -	partially degraded illite, chlorite, and kaolinite.
	Other Minerals -	quartz, feldspar and mica.
C-803.7'	Clay Minerals -	partially degraded illite, chlorite and kaolinite.
	Other Minerals -	quartz, feldspar and mica.
E-800.5'	Clay Minerals -	partially degraded illite, chlorite and kaolinite.
	Other Minerals -	quartz, mica, feldspar, possibly dolomite and calcite.

Table 18--(Continued)

Station		Mineralogy
F-791.2'	Clay Minerals -	partially degraded illite, chlorite and kaolinite.
	Other Minerals -	quartz, feldspar and mica.
E-826.0'	Clay Minerals -	partially degraded illite, chlorite and kaolinite.
	Other Minerals -	quartz, feldspar, dolomite and mica.
G-816.0'	Clay Minerals -	partially degraded illite, kaolinite and possibly chlorite.
	Other Minerals -	quartz, feldspar and mica.
E-835.5'	Clay Minerals -	partially degraded illite, chlorite and kaolinite.
	Other Minerals -	quartz, mica, dolomite and feldspar.
G-825.0'	Clay Minerals -	partially degraded illite, kaolinite and chlorite.
	Other Minerals -	quartz, feldspar and mica.

with graphite in a 1:1 weight ratio and fired at 1100° C. for twelve hours in an emission spectrograph (W. H. Bellis, 1969, personal communication). Unfortunately, this analysis did not reveal any differences in the substrate chemistry.

Based on the information that is available at this time, differences in the communities and their structures are not reflected by differences in sediment mineralogy and/or chemistry.

Trophic Levels (Food Webs)

Before concluding this section it is desirable to consider the feeding of these communities in more detail, i.e., trophic levels and their relationships. Initially it was hoped that a food web for each community defined in this study could be constructed. After gathering all the data and analyzing it, it became apparent that only one basic food web could be constructed. The four basic feeding categories were present in all four communities. Subdivision of these feeding types did not alter the trophic relationships sufficiently to warrant separate diagrams for each community. Therefore a generalized food web for all four benthic marine communities of the Wewoka was constructed and is included as Plate III. The heavy lines with arrows indicate the author's opinion as to what ate what. Each taxonomic entity encountered in the study of the 19 stations is included in this chart. By mentally eliminating those forms that do not occur in specific communities, it is possible to visualize the nature of the food web for any of the four communities. The data necessary for this elimination is provided in the discussions of each community. This food web is highly inadequate because only a few (phytoplankton and zooplankton) of the numerous groups of soft-bodied organisms that must have been present (Johnson, 1964, p. 119) are included.

Information as to the food, feeding type and mode of life of the various invertebrates has been obtained from the literature on both fossil and Recent forms. Foraminifers: Hyman (1940, p. 121), Yonge (1954a, 1954b), Nicol (1960, p. 205, 236), Phleger (1960) and Loeblich & Tappan (1964, p. C87). Porifera: Hunt (1925, p. 568), Yonge (1954a, 1954b), Jørgensen (1955, p. 418), Hartman (1958), Nicol (1960, p. 205-207) and Jørgensen (1966, p. 1). Coelenterates: Hunt (1925, p. 582-583), Hyman (1940, p. 392-393), Moore, Lalicker & Fischer (1952, p. 459), Yonge (1954b), Nicol (1960, p. 207, 236) and Jørgensen (1966, p. 4). Bryozoa: Hunt (1925, p. 574-575), Hyman (1951, p. 548-549), Yonge (1954b), Hyman (1959, p. 398) and Nicol (1960, p. 209-210). Brachiopods: Cooper (1937, p. 26), Craig (1952), Yonge (1954b), Hyman (1959, p. 583-590), Nicol (1960, p. 210-211), Rudwick (1965, p. H199-H214), Jørgensen (1966, p. 8) and McCammon (1968, p. 193; 1969). Scaphopods: Moore, Lalicker & Fischer (1952, p. 274), Yonge (1954a, 1954b) and Owen (1966, p. 27-29). Pelecypods: Hunt (1925, p. 571-573, 579), Yonge (1954a, 1954b), Jørgensen (1955, p. 428), Nicol (1960, p. 214-219, 233-235, 239-240), Stasek (1965), Jørgensen (1966, p. 66, 90), Owen (1966, p. 29-42) and Stanley (1968). Gastropods: Hunt (1925, p. 580, 589-591), Yonge (1954a, 1954b), Nicol (1960, p. 211-214, 233-235, 239-240), Jørgensen (1966, p. 53, 62-63), Owen (1966, p. 1-25) and Hyman (1967). Cephalopods: Scott (1940), Yonge (1954a, 1954b), Nicol (1960, p. 240) and Toomey (1966, p. 7). Echinoderms: Yonge (1954a, 1954b), Hyman (1955, p. 106, 211-212, 369-372, 553-557, 660-662), Nicol (1960, p. 209, 232, 233, 241), Anderson (1966, p. 329-357), Feder & Christensen (1966, p. 87-127), Fell (1966, p. 129-147), Fell (1966, p. 49-62), Jørgensen (1966, p. 109), Moore (1966, p. 73-85), Pawson (1966, p. 63-71) and Carter (1968). Arthropods: Moore, Lalicker & Fischer (1952, p. 536), Jørgensen (1955, p. 416, 428), Nicol (1960, p. 226, 229, 233, 235, 239), Benson (1961, p. Q56-Q63), Jørgensen (1966, p. 20) and Toomey (1966, p. 7). Polychaetes: Hunt (1925, p. 570), Yonge (1954a, 1954b), Jørgensen (1955, p. 415, 418, 427), Nicol (1960, p. 207) and Jørgensen (1966, p. 12). Fish: Hunt (1925, p. 593), Nicol (1960, p. 236, 241-244) and Toomey (1966, p. 7.)

One of the dominant elements composing the phytoplankton today are the diatoms with a geologic range of Early Mesozoic to Recent (Lohman, 1957, p. 731). Since these are absent from the older geologic units it is necessary to have some other biotic element fill this vital role of primary producers, unless as Lohman (1957, p. 732) suggests, they have been removed by solution from the Paleozoic sediments. For this reason the palynological samples were collected and analysis requested. Hopefully this study would reveal some clue as to what ultra-microscopic organisms were present that might have filled this role. Unfortunately this work has not yet been completed. It is assumed, in the absence of any empirical evidence, that the phytoplankton was composed of algal cells, spores, pollen and acritarches. Acritarches and chitinozoans are considered as part of the Silurian phytoplankton by Cramer (1969). Plant material included, but separated from the phytoplankton in the food web, are upright, encrusting and mat-forming algae. There is no available evidence, at this time, to support or deny the presence of these plants, but the quantity of browsing organisms (gastropods and echinoids) in these communities and the shallow water depths indicates that simple plants of such growth form could have been present. Also, Elias (1937, p. 411) mentions certain impressions in the Permian shales of Kansas that are considered as the thalloid-like branchlets of the Rhodophycophyta (red algae).

Other smaller members of this food web are the zooplankton, particular organic matter and bacteria. With the abundance of invertebrates it is permissible to assume that numerous larval stages of these organisms contributed to the zooplankton.

Particulate organic matter refers to the various sized particles of complex organic compounds in the sea that has been shown to be important food for certain invertebrates (Phleger, 1960, p. 111; Baylor & Sutcliffe, 1963; Riley, 1963; and McCammon, 1968, p. 193).

Bacteria, which must have been present, are considered as part of the detritus. Presumed bacteria have been recorded from Precambrian rocks (Cloud, 1968, p. 10-11) and thus must have been present during Wewoka deposition. Probably both anaerobic and aerobic forms occurred in the mud bottoms, depending on the physiochemical conditions.

Particulate feeders (of the food web), foraminifers and ostracodes would feed on the particulate organic matter in the water, on phytoplankton, certain zooplankton, detritus and the attached (upright, encrusting and mat-forming) algae. The critical factor in the feeding of these organisms was and is probably the size of the food particles. Basically the larger the animal the larger the particle it could ingest. However, foraminifers with their pseudopodia might engulf and digest particles larger than themselves. Food particle size would probably be more limiting in the ostracodes.

Suspension feeders have been divided into six different types, 4 epifaunal and 2 infaunal, in part after Ziegler, et al. (1968). These are attached, burrow-dwelling, pedunculate, spiny, infaunal, non-siphonate and vagrant. Attached are those that are rooted (crinoids) or cemented to the substrate. Cemented forms are the sponges, coelenterates, orbiculoids, bryozoans, non-pedunculated strophomenoid brachiopods and byssally attached pelecypods. Burrow-dwellers lived infaunally in burrows, such as linguloid brachiopods and polychaetes (worms). Pedunculate suspension feeders refer to those brachiopods which are epifaunal and are attached by means of a fleshy pedicle. The remainder of the brachiopods, productids and chonetids, are referred to as spiny suspension feeders. Infaunal pelecypods that lack a siphon are termed non-siphonate suspension feeders. Most of these live just below the sediment-water interface (Astarte) or partly exposed (Atrina) as shown by Stanley (1968, fig. 5). Vagrant suspension feeders are, in this food web, nektoplanktonic pelecypods (Pectinacea) and conularids (Moore, Lalicker & Fischer, 1952, p. 459).

All of these types feed on suspended material in the overlying waters which includes zooplankton, phytoplankton and particulate organic matter. Infaunal non-siphonate groups may have also fed on some of the bottom detritus. Articulate brachiopods are suggested as having fed largely on particulate organic matter (nutrients) by McCammon (1968, p. 193) who states:

> The elaborate development of the filtering system indicates the importance of selectivity of food material, and the reduced digestive system indicates that food selected yields little or no waste. Thus, nutrition from dissolved and colloidal nutrients would give a high-energy source with no waste remaining, whereas walled phytoplankton would yield waste during digestion.
>
> Laboratory experiments have shown that many forms of plankton are not acceptable to articulates while it has been possible to maintain brachiopods in the laboratory for over two years with only the addition of dissolved nutrients into the water.

This work is more fully presented in a recent paper by McCammon (1969).

Nuculoid palecypods are the primary organisms in the group classed as infaunal deposit feeders. These lamellibranchs are termed labial-palp deposit feeders by Stanley (1968) and the exact nature of feeding is described by Stasek (1965) for Yoldia ensifera. They live and probably did live below the sediment-water interface. Rhoads (1963) has described the manner in which certain nuculoids (Yoldia limatula) rework the bottom sediment. Holothurians are also considered infaunal deposit feeders but some present-day forms are epifaunal suspension feeders (Hyman, 1955, p. 211). This would mean placing them in with the vagrant suspension feeders as well as the infaunal deposit feeders. Organisms in this group feed on detritus and any organisms which might be in or on the bottom (particulate feeders). In addition they presumably eat any phyto- or zooplanktonic elements or particulate organic matter within their immediate feeding area. They are also considered as having fed on attached algae.

All the gastropods, scaphopods, trilobites and ostracodes are termed vagrant browsers, deposit feeders and scavengers. These are epifaunal forms which are capable of moving along the sea bottom. All of the organisms in this category might be considered infaunal since they probably burrowed along the bottom surface and even into it. Because of their versatile nature, the ostracodes are included in this category as well as with the particulate feeders. Detritus, attached algae and particulate feeders provide food for this variable group. Particulate organic matter, phytoplankton and zooplankton in the bottom sediments may have contributed some nutrition to these larger animals. There is no evidence of predation by the gastropods in any of the four communities, but such activity is possible. Some Recent snails are able to open the closed valves of a pelecypod in order to feed on the fleshy interior (Nicol, 1960, fig. 5.26). Perhaps some of the fossil gastropods had the same ability.

The remaining organisms, predators, have been divided into primary, secondary and tertiary. Primary predators are the lowest category in the predatory group and are fed upon by the higher categories (secondary and tertiary). Secondary predators are in turn fed upon by the tertiary forms and in this web there is no predator which preys on the tertiary predators. Tertiary predators would be represented by the fewest individuals, then the secondary forms and finally the primary ones with the greatest numbers of individuals of the total predatory category. All of the predators are epifaunal vagrants.

Primary predators are the echinoids, ophiuroids and asteroids. Hyman (1955, p. 55) indicates that some echinoids are actually predaceous but probably feed mostly on detritus (including dead and sick organisms), algae, particulate feeders and sessile suspension feeders (bryozoans and sponges). The other two echinoderm classes in this category probably feed on snails, trilobites?, nuculoid pelecypods and all of the suspension feeders except the vagrant forms. In this web the vagrant suspension feeders are nekto-planktonic and the primary predators are confined to the sea bottom. However, these suspension feeders probably do become prey for the nekto-planktonic predators (cephalopods and fish). The two higher classes of predators will also eat organisms in the other categories (suspension feeders, infaunal deposit feeders and vagrant browsers, deposit feeders and scavengers). They may also ingest detritus, particulate feeders, particulate organic matter, zooplankton and phytoplankton, but this is less realistic and arrows indicating such food have been omitted. The fishes are, at least in this scheme, immune to predation but cephalopods are a prey for them.

As any of the organisms in this food web die, plus death of the numerous soft-bodied forms that must have been present, they contribute to the detritus which provides food and nutrients for others so that the cycle is completed. We started with the phytoplankton which utilizes sunlight and nutrients from the water and air to provide energy for their vital processes and have ended with the death and decay of organisms (including tertiary predators) which contribute nutrients to the bottom sediments, the overlying water and hence, the air above.

Summary of Wewokan Marine Communities

Events recorded in a portion of the Wewoka claystone between sandstones Pwk-3a and Pwk-2 in Hughes County, Oklahoma, indicates that at least four benthic marine communities lived in the area during this claystone deposition. The succession of these communities (lowest to highest) is *Glabrocingulum*, Transitional, *Cleiothyridina* and *Mesolobus*.

All of these communities occurred in essentially nearshore environments, with the Cleiothyridina Community characterizing the most "normal" marine (farthest offshore) environment. Table 19 summarizes the inferred characteristics of each of these communities.

Table 19

Inferred Characteristics of the Benthic Marine Communities in the Wewoka Formation

Community	Turbulence	Energy	Substrate	Structure
Glabrocingulum	High	Low - Moderate	Clay	Infaunal Deposit
Transitional	High	Low - Moderate	Clay	Epi-Infaunal Deposit
Cleiothyridina	High - Moderate	Low - Moderate	Calcareous Clay	Epifaunal Suspension & Infaunal Deposit
Mesolobus	Moderate -	Moderate -	Clay, Silt & Sand	Epifaunal Suspension

The structure of each community in terms of feeding type and mode of life is presented in Figure 22. This is a graphic representation of the data presented in Tables 5, 9, 13, and 17 respectively. The histograms of this figure do not agree exactly with Craig and Jones (1966, fig. 1) which indicate that infaunal species are the most abundant on substrates of sand, muddy sand and mud. They were dealing with Recent sediments and organisms of the Irish Sea with soft-bodied animals included in the study. The following statements from Craig and Jones

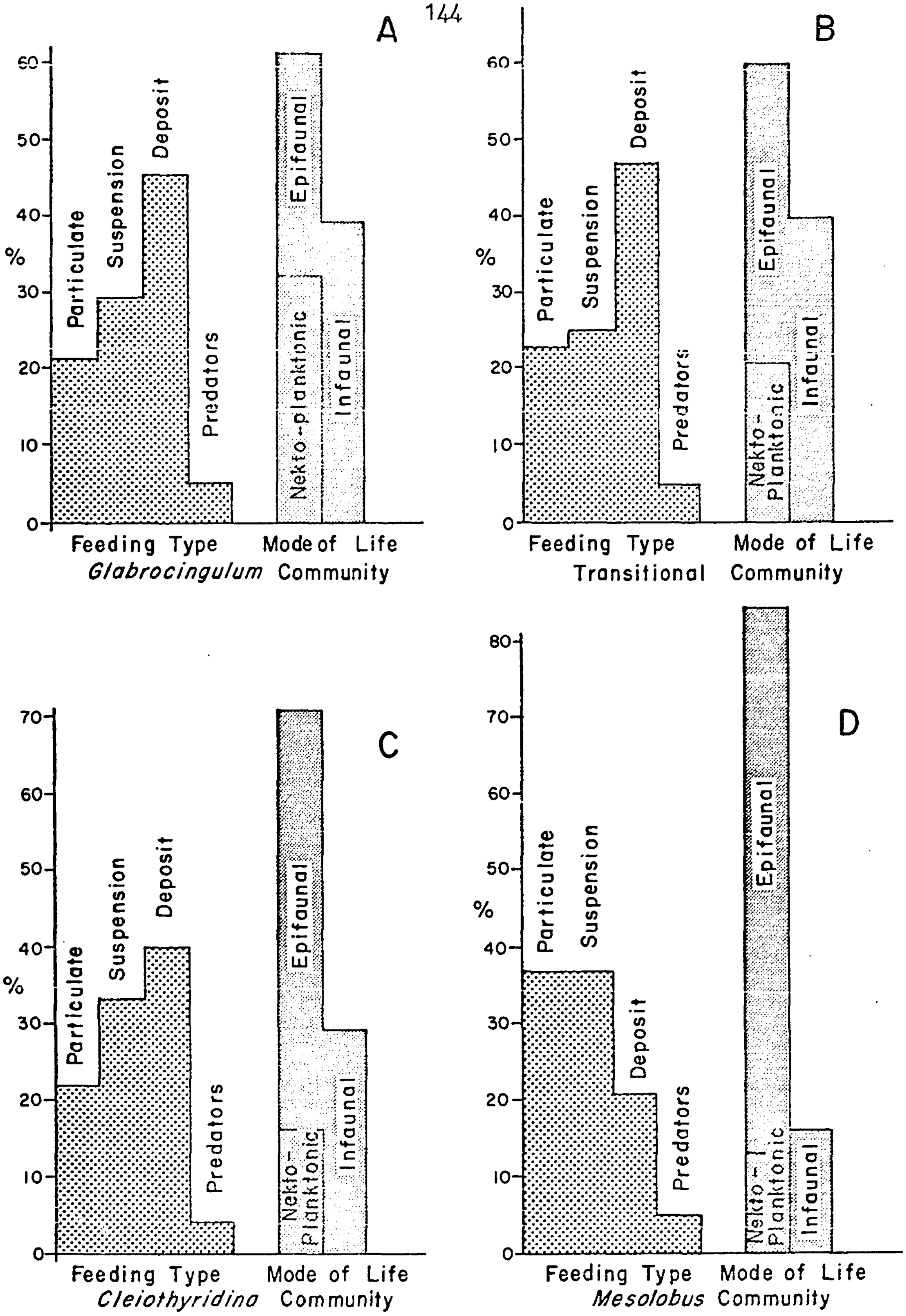


Figure 22. Percentages of species which compose each feeding type and mode of life for the four marine communities studied.

(1966, p. 30) sum up the relationship between marine benthos and the substrate and between modes of life and transportation and preservability:

> . . . the majority of epifaunal species are suspension feeders or carnivores and are associated with rocks or coarse-grained sediments. The majority of infaunal species are deposit feeders and are associated with fine-grained sediments. . . . epifauna, and benthos living in well-sorted sands, are more likely to be transported after death than most infauna. Over half of the species of epifauna but only one-third of the species of infauna have hard parts and are preservable as fossils.

These same generalizations apply to the Wewoka benthic marine communities.

SUMMARY

Nineteen fossil assemblages contained in a thin interval of the Middle Pennsylvanian Wewoka Formation in a small geographic area have been shown to represent mixed fossil assemblages as defined by Fagerstrom (1964, p. 1202). The major contributors to these fossil assemblages are further shown to have lived, died and been preserved at the collecting site (i.e., members of fossil communities). This has been accomplished through the use of size-frequency distributions, nature of preservation, mode of occurrence and orientation within the enclosing sediment, percentages of articulation, opposite valves, broken individuals and to some extent the dispersion of the fossils, population density, assemblage composition and diversity. Application of Q-mode cluster analysis using the coefficient of association developed by Dice (1945) resulted in a consolidation of these remanent fossil populations into four residual fossil communities. These communities are named for the dominant metazoan genus that occurs in each one. Stratigraphically, from the lowest to the highest, these are the: Glabrocingulum Community, Transitional Community, Cleiothyridina Community and Mesolobus Community.

The structure of each of the four communities was constructed on the basis of inferred feeding type and mode of life of the remanent community members. These Wewoka communities appear to have been structured in the same manner as Recent marine benthic communities of similar

substrates. Differences in the communities and their structures are not reflected in substrate mineralogy and/or chemistry. Food eaten by Recent invertebrates which are morphologically similar and/or taxonomically related to the fossil organisms was used as the basis for constructing a generalized food web for these four Pennsylvanian benthic communities.

Various depositional environments were inferred for each of the lithologic units defined in this investigation. These are, in ascending order; backswamp marshy area to tidal flat, shore margins of a partly restricted bay or delta front area, more open portions of a bay or prodelta area (more "normal" marine conditions), restricted bay (nearer shore area) with terrigenous detritus being added by a deltaic complex and deltaic sand deposition (distributary system). Three of the communities are compatible with the second, third and fourth environments. The Transitional Community characterizes an environment intermediate between the second and third.

Examination of shale/claystone sequences above and below the one studied in detail suggest that there is a cyclicity of environments within the Wewoka. This is reflected by the contained fossil assemblages and subtle changes in the claystone lithologies (fig. 9). Additional investigations of these fossil assemblages will probably show that they too represent benthic communities, which migrated in and out of the area depending on the physiochemical conditions. Fluctuations in the amount and type of terrigenous clastics carried into the area may be the primary key to the cyclicity of these communities.

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APPENDIX I

LOCATION AND DESCRIPTIONS OF MEASURED SECTIONS

This section contains the locations and descriptions of measured stratigraphic sections A through H and Locality A'. These descriptions are a combination of field notes, laboratory examinations and study of the washed residues. Each measured section was divided into beds on a lithologic basis in the field. Some of the thicker beds are broken down into smaller units with thicknesses of 5.0' or less. The bed numbers in this appendix are the same as those used in Plate II (cross section). All bed and sample numbers are prefixed with a letter designating the measured section.

Location of the sections are given in the standard legal manner and also with reference to the three points given on page 25 of the text. Elevations of the top and bottom of each section is also given.

Sample size, and hence the washed residues, was quite variable. No attempt was made to standardize the samples. Most were approximately 500 grams but some were 1000 grams or more in weight.

The washed residues consist primarily of the skeletal remains of marine invertebrates. These are listed alphabetically by phyla for each lithologic unit. Numbers following the scientific name refer to the total number of individuals of that taxonomic entity in the sample, unless the number is followed by the letter P. This letter denotes that this is the number of individuals observed per field of view. Field of view is defined as the circular area seen when an AO stereoscopic binocular microscope is equipped with 15X eyepieces and a 2X objective.

Color designations are in terms of the Geological Society of America Rock Color Chart, 1963.

Section A

Starts at an elevation of 767.03' and ends at an elevation of 788.08' near the center of NE¼, NE¼, SW¼, NE¼, Sec. 33, T. 7 N., R. 9 E., Hughes County, Oklahoma. In terms of the three reference points the top is: 1705.0' N.46°0'E. of point 1, 100.0' S. 73°0'W. of point 2 and 163.0' S.35°0'W. of point 3; the base is: 1768.0' N.45°30'E. of point 1, 66.0' N.66°0'W. of point 2 and 100.0' S.38°0'W. of point 3.

Measured in the southwest bank of the permanent stream, below (60.0' northwest of the center of) the W.P.A. dam. Start at an elevation of 767.03' (water level, fall, 1968); measure (beds A-1 through the lower part of A-6) 7.97' vertically and 40.0' horizontally in a southwest direction to an elevation of 775.0'; offset 20.0' horizontally in a southeast direction to an elevation of 775.0' in a small gully; measure (remainder of the beds) 13.08' vertically and 40.0' horizontally in an almost due west direction to an elevation of 788.08'.

Bed	Description	Thickness (feet)
A-1	Medium gray (N-5) to medium light gray (N-6), "crumbly," platy to fissile shale. Below water level - no sample collected. Total	0.2+
A-2	Fresh surface is a light olive gray (5Y6/1) to light gray (N-7) in color, weathers an earthy dark yellowish orange (10YR6/6) to dark reddish brown (10R3/4) and moderate yellowish brown (10YR5/4), argillaceous, fossiliferous, slightly pyritic, very fine grained, nodular carbonate mudstone with pockets and/or layers of medium gray (N-5) to dark gray (N-3) shale adhering to the nodules. Scattered brachiopodal and molluscan, resinous brown shell fragments occur with no obvious alinement	

Section A--Continued

Bed	Description	Thickness (feet)
A-2--(Continued)	of these fragments. Some complete specimens of the brachiopod Cruritbyris planoconvexa and the snail Glabrocingulum (Ananias) grayvillensis are present. Other organic material is not identifiable. The above named fossils are filled with a medium to dark gray carbonate mudstone. Finely disseminated pyrite is found in some of the snail shells and is particularly concentrated near the interior shell wall. Some of the snails may be in a more or less life position since the spire is directed upward at an angle of $\pm 45^{\circ}$ from the horizontal with the aperture parallel to bedding. A few of the brachiopods may also be in life position since the strongly convex valve is downward with the flatter dorsal valve upward. In both cases these orientations are not the same for all shells, some brachiopods have the dorsal valve down and snails occur with the spires at all angles to the horizontal (including straight downward).	
	The above mentioned reddish color is probably due to the oxidation (weathering) of contained iron compounds such as FeS_2 to form iron oxides or iron carbonates. This gives the nodular carbonate mudstone the appearance of ironstone nodules or concretions.	
	Sample A-1, Acetate peel; Washed residue of adhering shale: Ammodiscus sp. 1 Cruritbyris planoconvexa (broken pedicle valve) 1 Glabrocingulum (Ananias) grayvillensis 1 Fine to very fine sand sized, subangular to subrounded quartz grains 25 Total	0.15
A-3	Fresh a dark gray (N-3) to medium dark gray (N-4) weathers to a light gray (N-7) to medium light gray (N-6), hard, platy to fissile, fossiliferous, pyritic shale with a "nodular fracture" and slickensides. Nodular fracture corresponds to the conchoidal fracture of more indurated rocks such as limestones and cherts.	
	Fossils consist of Ammodiscus sp., Lingula cf. L. carbonaria, Nudirostra rockymontanum, Nuculopsis sp., Glabrocingulum (Ananias) grayvillensis and small, very	

Section A--Continued

Bed	Description	Thickness (feet)
A-3--(Continued)		

five carbonaceous debris. Specimens of Lingula are of various sizes, generally quite small, and lying parallel to bedding. The individuals of Nuculopsis sp. are also oriented parallel to bedding. Pyrite filled burrows? are oriented parallel to the bedding.

Iron sulfides (pyrite, marcasite and/or bornite) are common in this bed. These sulfides occur as elongate spindle-shaped bodies oriented parallel or at various angles to the bedding. Traces of iron sulfides on the bedding planes suggests local reducing conditions as a result of decaying organic material, perhaps worms. This may also be the explanation for the irregular shaped, nodular iron sulfide masses within the shale.

Sample A-2; Washed residue:

Ammodiscus sp.	25P
Bathysiphon sp.	15P
Reophax sp.	6P
?Tolypammina sp.	1P
Nudirostia rockymontanum (articulated)	3
Brachiopod shell fragments (unidentifiable)	1P
Nuculopsis sp. (2 articulated, 1 right valve)	3
Glabrocingulum (Ananias) grayvillensis	1
Molluscan shell fragments (unidentifiable)	1P
Hindeodellids	1P
Streptognathodus sp.	1P
Ozarkodina sp.	1P
Other Conodonts	1P
Fish debris	1P
Carbonaceous debris	3P
Irregular shaped iron sulfide masses	5P
Fine sand sized, rounded quartz grains	1P

Total 4.6

A-4 Fresh surface (dry) is medium dark gray (N-5) to medium gray (N-4), (wet) color grades from grayish black (N-2) to medium gray (N-4) through dark gray (N-3), argillaceous, discontinuous, dense, pyritic calcisiltite to carbonate mudstone nodules. Weathered surface is a grayish orange (10YR7/4) with numerous small gypsum crystals scattered over it.

Section A--Continued

Bed	Description	Thickness (feet)
A-4--(Continued)		
	Pyrite occurs as finely disseminated grains and as, what appears to be, burrow fillings. Near the top surface of the nodule sampled are irregularly filled cavities. The filling is some form of iron sulfide.	
	A few pencil line fractures are present, which have been filled with finely crystalline calcite (spar).	
	Basically a very homogeneous lithology.	
	Sample A-3; Acetate peel.	
	Total	0.2
A-5	Color of fresh surface is dark gray (N-3) to medium dark gray (N-4), weathered surface is a mixture of brownish grays and orange to rich rusty brown, fissile to platy, fossiliferous, pyritic shale with a "nodular" fracture in part.	
	Numerous pyrite and/or marcasite occurs as slender rods and irregular masses, probably due to decaying organic matter. These rods are oriented perpendicular as well as parallel to bedding and at all angles in between. The larger, more irregular, masses are parallel to bedding. Secondary gypsum crystals (selenite) occur along some bedding planes.	

Sample A-3A; Washed residue:

<u>Ammobaculites</u> sp.	1P
<u>Ammodiscus</u> sp.	1P
<u>Bathysiphon</u> sp.	1P
<u>Reophax</u> sp.	1P
<u>Nuculopsis</u> sp. (articulated)	1
<u>Polidevica</u> <u>bellistriata</u> (articulated)	1
Hindeodellids	1P
<u>Ozarkodina</u> sp.	1P
Pyritic plant fragments	1P
Faecal pellets	12P
Small secondary gypsum crystals	13P

Total 1.2

Section A--Continued

Bed	Description	Thickness (feet)
A-6	Fresh color is medium dark gray (N-4) to medium gray (N-5) and mottled with moderate brown (5YR3/4) to dark reddish brown (10R3/4) to light brown (5YR5/6) and dark yellowish orange (10YR6/6), weathers a mottled gray (N-6) to gray-brown, fossiliferous, pyritic, fissile to platy, slightly blocky shale with a "nodular" fracture in part. Contact with the underlying bed is gradational with 1.0' to 2.0' of interbedded lithologies. The fossils present, except the conularids and orbiculoids are internal molds and coated in part by gypsum. They are badly corroded and fragmented. Pyrite occurs as slender rods which are partly oxidized. Nature of occurrence and orientation is as in bed A-5 below.	

Sample A-4; Washed residue:

Bathysiphon sp.	1P
Conularia cf. C. crustula	7
Lophophyllum sp.	4
Lindstroemella cf. L. patula	1
Dictyoclostid brachiopods (pedicle valves)	3
Polidevica bellistriata (articulated)	1
Unidentifiable pelecypods	2
Glabrocingulum (Ananias) grayvillensis	6
Meekospira peracuta	3
Straparollus (Amphiscapha) catilloides	2
Orthocone	1
Coiled nautiloid	1
Pyritic plant fragments	1P
Faecal pellets	25P
Small secondary gypsum crystals	25P

Total 7.5

Bed	Description	Thickness (feet)
A-7	Dark yellowish brown (10YR4/2) to moderate yellowish brown (10YR5/4), some light gray (N-7) to mdeium light gray (N-6), earthy, soft, discontinuous ferrugineous, claystone nodules. Weathered portions are a moderate yellowish brown (10YR5/4). Nodules are coated by one centimeter thick layer of gypsum crystals. Incorporated withon one of these layers is a nuculoid pelecypod.	

Section A--Continued

Bed	Description		Thickness (feet)
A-7--(Continued)			
	Sample A-5; Washed residue:		
	Bathysiphon sp.	1P	
	Gypsum crystals	25P	
	Total		0.2
A-8	Light gray (N-7) and medium light gray (N-6) mottled with medium gray (N-5) and medium dark gray (N-4), platy to fissile, ferruginеous shale interbedded and interlaminated with moderate yellowish brown (10YR5/4) and grayish orange (10YR7/4), blocky to platy, ferruginous claystone. Some areas of dark reddish brown (10YR3/4) stains on bedding planes.		
	Numerous small, more or less straight circular holes, generally perpendicular to bedding. Some of these are lined with some form of iron oxide, others show a layer of black (pyritic?) material. There are similar features which are more irregular in shape and size and associated with a thin film or coating of "rust." Darker areas of the shale which suggest mottling are found with such a hole at the center. This suggests that these were originally pyrite rods and irregular bodies. It is plausible to assume that there were soft-bodied burrowers which died in their burrows. Decay of these resulted in iron sulfides and later oxidization produced what is observed.		
	Sample A-5A; Washed residue:		
	Bathysiphon sp.	2P	
	Lindstroemella cf. L. patula	2	
	Nuculoid pelecypods (internal molds)	3	
	Trepospira depressa (internal molds)	2	
	Fish fragment?	1	
	Carbonized plant debris	<1P	
	Small gypsum crystals (secondary)	10P	
	Total		3.0
A-9	Light olive gray (5Y6/1) to (5Y5/2) to pale olive (10Y6/2) and grayish orange (10YR7/4) with dark yellowish orange (10YR6/6) stains on the bedding planes. The color is hard to describe because it is		

Section A--Continued

Bed	Description		Thickness (feet)
A-9--(Continued)			
	a mottling of several hues and shades. Generally this bed is a yellowish brown to grayish green, platy to blocky claystone with ironstone nodules on the weathered surface. Pyrite is very rare, as is gypsum.		
	Contact with underlying bed (A-8) is gradational.		
	Sample A-6; Washed residue:		
	Ammodiscus sp.	5P	
	Bathysiphon sp.	10P	
	Paleotextularia sp.	1P	
	Tolypammina sp.	1P	
	Pseudozygopleurids (internal mold)	1	
	Streptognathodus sp.	1P	
	Fish debris	<<1P	
	Faecal pellets	31	
	Carbonaceous plant debris	10	
	Gypsum crystals (secondary)	15	
	Total		2.0+
A-10	Yellowish brown to gray, clayey soil. No sample collected.		
	Total		2.0+
	TOTAL THICKNESS		21.05+

Locality A'

At an elevation of 766.0' in a stream bank at SE¼, NW¼, NW¼, Sec. 33, T. 7 N., R. 9 E., Hughes County, Oklahoma. In terms of the three reference points this locality is 1757.0' N.41°0'E. of point 1, 200.0' N.57°0'W. of point 2 and 168.0' N.87°30'W. of point 3.

Located near water level at the mouth of the first large gully on the northeast side of the permanent stream below (200.0' northwest of the center of) the W.P.A. dam.

At this locality the nodular bed (A-2) of Section A is well exposed. The shales between the nodules and above and below them for a

Locality A'--Continued

distance of 0.5' to 1.0' are also well exposed. It was studied to obtain more information about this interval and the nodular horizon and associated shales are considered separately.

Nodules Light olive gray (5Y6/1) to light gray (N-7), weathers dark yellowish orange (10YR6/6) to dark reddish brown (10R3/4) and moderate yellowish brown (10YR5/4), highly argillaceous, highly fossiliferous, slightly pyritic, rather continuous, very fine grained nodular carbonate mudstone with pockets and layers of medium gray (N-5) to dark gray (N-3) shale adhering to the nodules.

There are scattered resinous brown shell fragments of molluscans and brachiopods with no obvious alinement. Complete specimens of Crurithyris planoconvexa, Trepospira depressa and Glabrocingulum (Ananias) grayvillensis are present in large numbers. These fossils are filled with a medium to dark gray carbonate mudstone. Finely disseminated pyrite is common in some of the molluscan shells and is concentrated near the interior shell walls.

Surfaces of the nodules are covered with fossils. These include the brachiopods Nudirostra rockymontanum and Crurithyris planoconvexa. It is possible that some of the specimens of Nudirostra rockymontanum are in life position, but certainly not all since some are related to the bedding in such a way that the valves could not have opened. This is also true for Crurithyris planoconvexa as noted for bed A-2. There are fragments of what appear to be nuculoid pelecypods, but the only complete specimens are of the Astartacea, the genus Astartella cf. A. concentrica. According to Stanley, 1968, these forms as preserved in this lithology, could not be in life position. They are still articulated, as are the brachiopods, but the anterior is upward and posterior downward. This is opposite to what Stanley illustrates. Gastropods are represented by a large number of Glabrocingulum (Ananias) grayvillensis and an occasional Trepospira depressa. The latter are oriented with their spires parallel to the bedding. Some of the former type may be in, or near, life position since the spire is pointed upward at $\pm 45^{\circ}$ angle from the vertical. Others have the spire pointing downward. Lindstroemella cf. L. patula is represented by two specimens. One piece of fish debris was also observed.

Locality A'--Continued

Nodules--(Continued)

All of the fossils are well preserved and details of ornamentation are easily observable. With all the preserved organisms there is no evidence of burrowing in this bed.

Sample A'-carbonate, Acetate peel.

Allied Shale

Medium dark gray (N-4) weathering to a medium gray (N-5), fissile to platy, moderately hard, fossiliferous shale. Tends to be splintery and has a slightly "nodular" fracture. Some stains of moderate yellowish brown (10YR5/4) to dark reddish brown (10R3/4).

Sample A'-shale; Washed residue:

Ammobaculites sp.	1P
Ammodiscus sp.	2P
Bathysiphon sp.	3P
Endothyranella sp.	1P
Tolypammina sp. (on clam)	1
Lingula cf. L. carbonaria	1P
Lindstroemella cf. L. patula	3
Crurithyris planoconvexa (articulated and of various sizes)	50+
Nudirostra rockymontanum (articulated and of various sizes)	20+
Plagioglypta sp.	1P
Anthraconeilo taffania (articulated mostly small individuals)	12
Astartella cf. A. concentrica (articulated)	3
Nuculopsis girtyi (9 articulated, 1 left valve)	10
Nuculopsis (Palaeonucula) wewokana (articulated and of various sizes)	15
Paleyoldia glabra (small and articulated)	2P
Polidevica bellistriata (12 articulated, 1 left valve)	13
Bellerophon (Pharkidonotus) pericarinatus	1
Euphemites carbonarius	3
Glabrocingulum (Ananias) grayvillensis (various sizes)	50+
Ianthinopsis sp.	1P
Pseudozygopleurids	1P
Trepospira depressa (various sizes)	11
Pseudorthoceras sp. (broken)	2P
?Gastrioceras sp. (small)	1P
Unidentifiable shell fragments	50+

Locality A'--Continued

Allied Shale--(Continued)

Bairdia sp. (articulated)	1P
Crinoid columnals	1
Conodont fragments	1P
?Fish debris	<1P
Wood fragments	1P
Pyritic masses	2
Fine to very fine sand size, subrounded to subangular quartz grains	25+

Section B

Starts at an elevation of 762.5' at the mouth of a gully and ends at the head of the gully at an elevation of 783.75'; along West line of SE$\frac{1}{4}$, NW$\frac{1}{4}$, NW$\frac{1}{4}$, Sec. 33, T. 7 N., R. 9 E., Hughes County, Oklahoma. In terms of the three reference points the top is: 1590.0' N.37°30'E. of point 1, 350.0' N.83°0'W. of point 2 and 353.0' S.80°30'W. of point 3; the base is: 1730.0' N.35°30'E. of point 1, 362.0' N. 58°30'W. of point 2 and 320.0' N.74°30'W. of point 3.

Measured along the west and northwest side of the first large gully on the southwest side of the permanent stream, below (350.0' northwest of the center of) the W.P.A. dam. Start at an elevation of 762.5' (water level, fall, 1968); measure (beds B-1 through the lower part of B-8) 13.10' vertically and 60.0' horizontally in a southwest direction to an elevation of 775.6'; then measure (remainder of beds) 8.15' vertically and 100.0' horizontally in an almost due south direction to an elevation of 783.75'.

Bed	Description	Thickness (feet)
B-1	Medium dark gray (N-4) to dark gray (N-3) on fresh surface and medium gray (N-5) to medium light gray (N-6) on weathered surface, fissile to platy, fossiliferous shale with ironstone nodules, "nodular" fracture, slickensides and some jointing. Ironstone nodules are moderate yellowish brown (10YR5/4) exteriorly and medium dark gray (N-5) to medium light gray (N-6) interiorly, slightly calcareous, small (1 centimeter or less in diameter), hard and highly argillaceous.	

Section B--Continued

Bed	Description		Thickness (feet)
B-1--(Continued)			
	Sample B-1B'; Washed residue:		
	Ammodiscus sp.	1P	
	Bathysiphon sp.	2P	
	Endothyranella sp.	1P	
	Tolypammina sp. (encrusting shell fragments)	3P	
	Inarticulate brachiopod fragments	1P	
	Crurithyris planoconvexa (articulated and of various sizes)	7	
	Nudirostra rockymontanum (1 articulated, 1 fragment)	2	
	Plagioglypta sp.	3P	
	Astartella cf. A. concentrica (articulated)	1	
	Nuculopsis (Palaeonucula) wewokana (articulated)	1P	
	Paleyoldia glabra (small and articulated)	1P	
	Polidevica bellistriata (small and articulated)	4P	
	Glabrocingulum (Ananias) grayvillensis (various sizes)	7P	
	Pseudozygopleurids (small)	1P	
	Trepospira depressa (various sizes)	1P	
	Gastrioceras sp. (small)	1P	
	Molluscan and brachiopod shell fragments	50+	
	Bairdia sp. (articulated)	1P	
	Ozarkodina sp.	1	
	Idiognathodus sp.	1	
	Fine to very fine sand size, rounded quartz grains	1P	
	Total		1.0
B-2	Light olive gray (5Y5/2) to medium light gray (N-6) on fresh surface, dark yellowish orange (10YR6/6) to dark reddish brown (10R3/4) and moderate yellowish brown (10YR5/4) weathered, fossiliferous, slightly pyritic, continuous highly argillaceous, very fine grained nodular carbonate mudstone with adhering shale. Adhering shale is lithologically as bed B-1 but is a coquina of fossil shells. Etched surface of nodules reveals possible burrowing, abundant molluscan shell fragments and thin veins of crystalline calcite (spar). Surfaces of nodules are covered with fossils: Crurithyris planoconvexa, Nudirostra rockymontanum, Astartella cf. A. concentrica, Nuculopsis (Palaeonucula)		

Section B--Continued

Bed	Description	Thickness (feet)

B-2--(Continued)

wewokana, Nuculopsis girtyi, Polidevica bellistriata, Glabrocingulum (Ananias) grayvillensis, Knightites (Cymatospira) montfortianum, Treposspira depressa, and ?Gastrioceras sp. The articulated Nudirostra and the bellerophontid Knightites may be in life position. The brachiopod has the pedicle valve up and is inclined upward with respect to bedding. The aperture of the snail is down and parallel to bedding.

Sample B-1A', Acetate peel; Washed residue of adhering shale:

Ammobaculites sp.	1P
Ammodiscus sp.	<1P
Earlandinita sp.	4P
Endothyranella sp.	2P
Tolypammina sp. (on brachiopod shells)	<1P
Ramose and Encrusting Bryozoans (fragments)	<1P
Crurithyris planoconvexa (articulated and of various sizes)	8P
Mesolobus euampygus (52 articulated of various sized, 2 brachial and 1 pedicle valve)	55+
Nudirostra rockymontanum (articulated)	1
Astartella cf. A. concentrica (2 articulated, 1 left valve and 8 fragments)	11
Nuculopsis girty (3 articulated 1 fragment)	4
Nuculopsis (Palaeonucula) wewokana (articulated)	1
Polidevica bellistriata (articulated and of various sizes)	8
Euphemites carbonarius	2
Glabrocingulum (Ananias) grayvillensis (various sizes)	32+
Knightites (Cymatospira) montfortianum (various sizes)	6
Meekospira peracuta	6
Pseudozygopleurids	2P
Treposspira depressa	1
Pseudorthoceras sp. (broken)	2
?Gastrioceras sp.	1
Molluscan and brachiopod shell fragments	12P
Bairdia sp. (articulated)	<1P
Crinoid debris	3P
Echinoid spines (broken)	2P

Section B--Continued

Bed	Description		Thickness (feet)
Bed B-2--(Continued)			
	?Fish debris	1P	
	Pyrite grains	1P	
	Fine sand size, subangular to subrounded quartz grains	1P	
	Total		0.15
B-3	Dark gray (N-3) to grayish black (N-2) on fresh surface, weathered color medium dark gray (N-4) to medium gray (N-5) with some moderate brown (5YR4/4) stains on surfaces perpendicular to bedding, very hard, fissile to platy, pyritic, slightly fossiliferous shale with "nodular" fracture.		
	Pyrite occurs as fossil replacements, irregular masses (burrows?) parallel and perpendicular to bedding and as finely disseminated grains. The irregular masses are either cylindrical branching tubes (from 1.0 to 5.0 mm. in diameter) or nodules up to 15 mm. long. These latter forms may be coprolites. Some sphalerite and calcite crystals occur with the pyrite.		
	Sample B-1; Washed residue:		
	Ammodiscus sp.	2P	
	Bathysiphon sp.	1P	
	Reophax sp.	1P	
	Lindstroemella cf. _L_. _patula_	5	
	Anthraconeilo _taffania_ (articulated, internal mold)	1	
	Nuculopsis _girtyi_ (articulated in pyrite nodule)	2	
	Polidevica _bellistriata_ (articulated in pyrite nodule)	1	
	Hindeodellids	<1P	
	Carbonaceous fragments	4P	
	Pyritic masses (cylindrical to conical and irregular)	30+	
	Crystals of pyrite, calcite and sphalerite	<<1P	
	Total		4.0
B-4	Grayish black (N-2) to medium gray (N-4) on fresh surface, medium dark gray (N-5) to medium gray (N-4)		

Section B--Continued

Bed	Description	Thickness (feet)
B-4--(Continued)		
	weathered, argillaceous, slightly pyritic, hard, discontinuous calcisiltite to carbonate mudstone. No fossils nor evidence of burrowing. Finely disseminated pyrite and a few thin calcite filled fractures. Some nodules are coated with gypsum crystals.	
	Sample B-1A; Acetate peel.	
	Total	0.2
B-5	Dark gray (N-3) to grayish black (N-2) on fresh surface, medium dark gray (N-4) to medium gray (N-5) weathered, hard, platy to fissile, splintery, pyritic, fossiliferous shale with "nodular" fracture.	
	Pyrite occurs as fossil replacement, slender rods, small nodules and smudges on the bedding planes. <u>Lingula</u> cf. <u>L</u>. <u>carbonaria</u> and <u>Lindstroemella</u> cf. <u>L</u>. <u>patula</u> are often completely replaced by pyrite. The latter are probably in life position but the former are oriented parallel to bedding. Pyrite rods are oriented at various angles with respect to bedding.	
	Fish denticles are also commonly found and less commonly a small bivalved crustacean, possibly a conchostracan.	
	Sample B-1B; Washed residue:	
	<u>Ammodiscus</u> sp. 1P	
	<u>Bathysiphon</u> sp. <1P	
	<u>Reophax</u> sp. <1P	
	Nuculoid pelecypods (articulated and corroded) 2	
	Conodont fragments <1P	
	Pyrite masses (coprolites?) 2	
	Total	1.6
B-6	Medium dark gray (N-4) to dark gray (N-3) on fresh surface, medium gray (N-5) weathered, hard, fissile to platy, splintery, fossiliferous, pyritic shale which breaks with a "nodular" fracture. Contact with underlying bed is gradational.	

Section B--Continued

Bed	Description	Thickness (feet)

B-6--(Continued)

Pyrite occurs as slender rods, small irregular nodules and smudges on the bedding planes. Rods vary in diameter from 0.5 to over 1.0 millimeter and are oriented at random with respect to bedding. Smudges are a brassy to iridescent color. The nodules may represent coprolites. Secondary gypsum (selenite crystals) are common. Small gypsum crystals coat some of the fossils.

Sample B-2; Washed residue:

Bathysiphon sp.	1P
Reophax sp.	1
Lophophyllum cf. L. profundum (broken)	2
Fenestrate bryozoans fragments (broken)	<1P
Lindstroemella cf. L. patula	2
Crurithyris planoconvexa (5 articulated, 2 brachial and 1 pedicle valves, various sizes)	8
Nudirostra rockymontanum (articulated, corroded)	1
Astartella cf. A. concentrica (broken)	1
Nuculopsis (Palaeonucula) wewokana (articulated)	1
Polidevica bellistriata (articulated)	1
Bellerophontid snail	1
Glabrocingulum (Ananias) grayvillensis (broken)	4
?Straparolus (Amphiscapha) sp. (broken)	1
Trepospira depressa (broken)	1
Goniatite (unidentifiable)	1
Cavellina sp.	<1P
Healdia sp. (corroded)	1
Bairdia sp.	<1P
Crinoid columnals	<1P
Scolecodonts	8
Ozarkodina sp.	1
Idiognathodus sp.	<1P
Hindeodellids	1P
Fish debris	<1P
Pyritic masses (? burrows)	1P
Pyritized plant stems	2P

Total 5.1

Section B--Continued

Bed	Description	Thickness (feet)
B-7	Medium dark gray (N-4) to medium gray (N-5) on fresh surface, light olive gray (5Y5/2) to moderate yellowish brown (10YR5/4) weathered, hard, dense, argillaceous, discontinuous nodular horizon of calcisiltite to carbonate mudstone. Some finely disseminated pyrite, pyrite filling ?burrows and carbonaceous material is present in some nodules. Exteriors of nodules are coated with selenite crystals, large and small. No fossils occur in this bed.	
	Sample B-3; Acetate peel.	
	Total	0.2
B-8	Light gray (N-7) and medium light gray (N-6) mottled with medium gray (N-5) and medium dark gray (N-4), platy to fissile, fossiliferous, shale interbedded and interlaminated with moderate yellowish brown (10YR5/4) and grayish orange (10YR7/4), fissile to platy, slightly blocky claystone. Some dark reddish brown (10R3/4) stains on some of the bedding planes.	
	Numerous small, more or less straight circular holes, generally perpendicular to bedding. Some are lined with iron oxide and others with a dark (pyritic?) material. The mottled areas often have these holes in the center. Suggests that these were once iron sulfide rods that have been oxidized. Similar to bed 8 of Section A.	

Sample B-4; Washed residue:

Bathysiphon sp.	<1P
Anthraconeilo sp. (articulated internal mold)	1
Trepospira _depressa_ (broken)	3
Scolecodonts	4
Hindeodellids	1P
Idiognathodus sp. (fragment)	1
Iron oxide rods	3P
Small gypsum crystal (secondary)	30P

	Total	1.9
B-9	Light olive gray (5Y6/1) to (5Y5/2) to pale olive (10Y6/2) and grayish orange (10YR7/4) with dark yellowish orange (10YR6/6) stains on bedding planes,	

Section B--Continued

Bed	Description		Thickness (feet)
B-9--(Continued)			
	platy to blocky claystone with ironstone nodules. Contact with underlying bed is gradational. Nodules are less than 5 centimeters in maximum diameter (down to 5 millimeters) with grayish orange (10YR7/4) exteriors and light brown (5YR5/6) interiors.		
	Sample B-5; Washed residue:		
	Ammodiscus sp.	3P	
	Bathysiphon sp.	<1P	
	Reophax sp.	<1P	
	Unidentifiable horn coral (replaced by iron oxide)	1	
	?Glabrocingulum (Ananias) sp. (internal mold)	1	
	Conodonts (unidentifiable)	<1P	
	Gypsum crystals and aggregates (secondary)	30P	
	Total		5.1
B-10	Yellowish brown to gray, clayey soil. No sample collected.		
	Total		2.0+
	TOTAL THICKNESS		21.25+

Section C

Starts at an elevation of 764.90' near NE cor. SE¼, SW¼, NW¼, NW¼, Sec. 33, T. 7 N., R. 9 E. in stream bed and ends at an elevation of 814.7' near NE cor. NE¼, NW¼, SW¼, NW¼, Sec. 33, T. 7 N., R. 9 E., Hughes County, Oklahoma, at the north edge of farm pond. In terms of the three reference points the top is: 1418.0' N.23°30'E. of point 1, 752.0' N.83°30'W. of point 2 and 750.0' S.88°0'W. of point 3; the base is: 1748.0' N.21°0'E. of point 1, 800.0'N.59°0'W. of point 1 and 752.0' N.66°0'W. of point 3.

Measured along the west side of the second large gully on the southwest side of the permanent stream, below (800.0' northwest of the center of) the W.P.A. dam and along a bare, east sloping area on the

Section C--Continued

north side of a small farm pond. Start at an elevation of 764.9' (water level, fall, 1968); measure (beds C-0 through C-10) 16.7' vertically and 130.0' horizontally in a direction slightly west of north to an elevation of 781.6'; proceed along dry, sparsely wooded stream bed (bed C-11), first due east, then swinging around gradually to due south and finally nearly due west to an elevation of 793.1' below the west end of a farm pond dam; measure (beds C-12 through C-14) 4.1' vertically and 30.0' horizontally in this westerly direction; then measure (beds C-15 through the lower 5.0' of C-17) 8.0' vertically and 20.0' horizontally in a southwest direction; measure (remainder of beds) 9.4' vertically and 50.0' horizontally slightly north of due west along the north side of farm pond to an elevation of 814.7'.

Bed	Description	Thickness (feet)
C-0	Dark gray (N-3) to medium dark gray (N-4) on fresh surface, medium gray (N-5) to medium light gray (N-6) weathered, hard, fissile to platy, pyritic, fossiliferous shale with a "nodular" fracture. Small secondary gypsum crystals occur around fossils and along same bedding planes. Lingula is oriented with its long axis parallel to bedding.	

Pyrite occurs as slender rods, smudges on bedding planes and larger (up to 10 mm. in diameter and 13 cm. long) nodules. Rods are oriented at various angles to the bedding. Smudges are brassy to iridescent areas. Nodules may be coprolites.

Sample for palynological study collected from this bed.

Sample C-1; Washed residue:

?Bathysiphon sp.	<1P
Conularia cf. C. crustula	1
Lophophyllum sp.	1
Lingula cf. L. carbonaria	1
Lindstroemella cf. L. patula	3
Small productoid (articulated)	1
Astartella cf. A. concentrica (small, articulated)	1
Nuculopsis (Palaeonucula) wewokana (small, articulated)	1
Glabrocingulum (Ananias) grayvillensis	1
Straparolus (Amphiscapha) sp.	3
Trepospira depressa	1
Goniatite (small)	1
Unidentifiable brachiopod and molluscan shell fragments	<1P

Section C--Continued

Bed	Description	Thickness (feet)
C-0--(Continued)		
	Ostracodes (articulated and including Bairdia sp., Healdia sp. and Hollinella sp.) <1P	
	Scolecodonts 8	
	Conodonts (including Idiognathodus sp., Streptognathodus sp., Cavusgnathus sp. and Hindeodellids) <1P	
	Fish debris (some pyritized) <1P	
	Pyritized plant debris 1P	
	?Faecal pellets (pyritized) 3	
	Total	3.2
C-1	Grayish black (N-2) to medium gray (N-4) on fresh surface, medium dark gray (N-5) to medium gray (N-4) weathered, hard, highly argillaceous, discontinuous, dense, fine grained, slightly pyritic calcisiltite or carbonate mudstone nodules. Pyrite occurs as circular to irregular elongate masses in cross section suggesting burrow fillings. Some sphalerite associated with pyrite. Occasionally gypsum crystals coat part of the nodule surface. Sample C-1A; Acetate peel.	
	Total	0.2
C-2	Dark gray (N-3) to medium dark gray (N-4) on fresh surface, medium gray (N-5) to medium light gray (N-6), hard, fissile to platy, fossiliferous, pyritic, jointed shale with "nodular" fracture. Two sets of joints, one set strikes N.35°0'E. with near vertical dip, the other set is perpendicular to the first one, also with near vertical dip. Pyrite occurs as rods (±2.0 mm. in diameter and slightly larger), irregular nodular masses and smudges on the bedding planes. Rods are oriented parallel and perpendicular to bedding and at all angles in between. Large (25 mm. x 90 mm. x 5 mm.) and small secondary gypsum crystals are common. Smaller ones occur along joints and bedding planes.	

Section C--Continued

Bed	Description	Thickness (feet)
C-2--(Continued)		

Some of the nuculoid pelecypods appear to be in life position (Stanley, 1968).

Sample C-2; Washed residue:

Ammodiscus sp.	2
Bathysiphon sp.	<1P
Reophax sp.	<1P
Tolypammina sp.	1P
Conularia cf. C. crustula	1
Lindstroemella cf. L. patula	5
Crurithyris planoconvexa (articulated)	2
?Anthraconeilo taffania (small, articulated)	3
Nuculopsis girtyi (articulated)	3
Polidevica bellistriata (fragments)	2
Straparolus (Amphiscapha) sp. (fragment)	1
Trepospira depressa (small)	6
Worthenia sp.	1
Scolecodonts	5
Hindeodellids	<1P
Ozarkodina sp.	<1P
Fish debris	<1P
?Pyritized plant debirs	1P
Pyritic rods	19

Total 1.5

C-3 Medium dark gray (N-4) on fresh surface, medium light gray (N-6) weathered, hard, fissile to platy, jointed, fossiliferous, pyritic shale with "nodular" fracture. Contact with underlying bed is gradational.

Pyrite occurs as irregular masses (burrow fillings?), smudges on bedding planes, and small bead-like grains. Jointed as bed below with small selenite crystals along bedding planes.

Sample C-2A; Washed residue:

Ammodiscus sp.	<1P
Bathysiphon sp.	1P
Reophax sp.	<1P
Conularia cf. C. crustula	3
Lindstroemella cf. L. patula	4
Anthraconeilo taffania (articulated)	1

Section C--Continued

Bed	Description		Thickness (feet)
C-3--(Continued)			
	Nuculopsis sp. (fragment)	1	
	Glabrocingulum (*Ananias*) *grayvillensis*	1	
	Straparolus (*Amphiscapha*) *catilloides*	1	
	Pseudorthoceras sp. (fragment)	1	
	Coiled cephalopod (fragment)	1	
	Healdia sp.	1	
	Scolecodonts	7	
	?*Gnathodus* sp.	2	
	Hindeodellids	3	
	Idiognathodus sp.	3	
	Ozarkodina sp.	2	
	?*Steptognathodus* sp.	2	
	Pyritic masses (coprolites? or burrow fillings)	17	
	Total		2.5
C-4	Grayish black (N-2) to medium gray (N-4) on fresh surface, medium dark gray (N-5) to medium gray (N-4) weathered, hard, highly argillaceous, discontinuous, dense, fine-grained, slightly pyritic calcisiltite or carbonate mudstone nodules. Pyrite occurs as circular to irregular elongate masses in cross section suggesting burrow fillings. Sample C-3; Acetate peel.		
	Total		0.2
C-5	Medium dark gray (N-5) to medium gray (N-5) on fresh surface, medium light gray (N-6) to medium gray (N-5) weathered, fissile to platy, "crumbly", pyritic, slightly fossiliferous, shale with "nodular" fracture. Pyrite occurs as smudges on the bedding planes and as small granular masses. Gypsum crystals occur along bedding planes. Sample C-3A; Washed residue:		
	Ammobaculites sp.	<1P	
	Ammodiscus sp.	1P	
	Bathysiphon sp.	2P	

Section C--Continued

Bed	Description		Thickness (feet)
C-5--(Continued)			
	Reophax sp.	<1P	
	Scolecodonts	1	
	Ozarkodina sp.	1	
	Streptognathodus sp.	1	
	Pyrite replaced plant debris	<1P	
	Pyritic faecal pellets? and burrow fillings?	<1P	
	Total		1.3
C-6	Yellowish gray (5Y7/2) to moderate yellowish brown (10YR5/4) and light brown (5YR5/6), yellowish gray (5Y7/2) to light olive gray (5Y6/1) internally with outer layers weathering to various shades of brown and orange, moderately hard, slightly calcareous, highly argillaceous, discontinuous ironstone nodules. Some nodules are coated with gypsum crystals. No identifiable fossils with the exception of some tentatively identified brachiopod shell fragments. Some small grains of pyrite are visible on the polished and etched surface. Sample C-4; Acetate peel.		
	Total		0.1
C-7	Medium dark gray (N-4) to medium gray (N-5) on fresh surface, medium light gray (N-6) to medium gray (N-5) weathered, platy to fissile, in part blocky, "crumbly," shale with "nodular" fracture; interbedded and interlaminated with a softer, yellowish gray (5Y7/2) to moderate yellowish brown (10YR5/4), blocky to platy claystone. Some small gypsum crystals associated with areas of dark yellowish orange (10YR6/6) and light (5YR5/6) to moderate (5YR4/4) brown color in latter lithology. Sample C-5; Washed residue:		
	Ammodiscus sp.	9P	
	Bathysiphon sp.	2P	
	Reophax sp.	<1P	

Section C--Continued

Bed	Description		Thickness (feet)
C-7--(Continued)			
	Scolecodonts	2	
	Hindeodellids (fragments)	<1P	
	Idiognathodus sp.	1	
	Unidentifiable conodonts (fragments)	1	
	Fish debris	1	
	?Faecal pellets	2P	
	Gypsum crystals	5P	
	Total		0.4

C-8 Light gray (N-7) to medium light gray (N-6) and yellowish gray (5Y7/2) to pale yellowish brown (10YR6/2) and grayish orange (10YR7/4) on fresh surface, darker shades and hues of these same colors on weathered surface, blocky to platy, ferruginous (ironstone concretions and/or nodules are common), fossiliferous claystone. Numerous orange and brown stains on bedding planes. Contact with underlying bed (7) is gradational.

Pyrite is not present, but numerous, small (±1.0 mm. in diameter), slender rods of iron oxide are present. These rods are oriented approximately perpendicular to bedding. Sample of float collected.

Sample C-6; Washed residue:

Ammodiscus sp.	13P
Bathysiphon sp.	1P
Lituotuba sp.	1
Reophax sp.	<1P
Ramose bryozoans (fragments of colonies)	2
Crurithyris planoconvexa (articulated internal mold)	1
Glabrocingulum (A.) grayvillensis (internal mold)	1
Pseudorthoceras sp.	1
Healdia sp.	1
?Cavellina sp.	1
?Scolecodonts	≪1P
Gnathodus sp.	1
Hindeodellids (fragments)	<1P
Idiognathodus sp.	1
Ozarkadina	2
Streptognathodus sp.	3

Section C--Continued

Bed	Description	Thickness (feet)
C-8--(Continued)		

Unidentifiable conodonts (fragments)	<1P
Fish debris	≪1P
Faecal pellets	15P
Gypsum crystals	7P

Total 3.0

C-9 Dark yellowish orange (10YR6/6) to grayish orange (10YR7/4) on fresh surface, moderate brown (5YR4/4) and light brown (5YR5/6) to light gray (N-7) weathered, soft, discontinuous, non-fossiliferous horizon of ironstone nodules. Occasional small gypsum crystals adhere to the surface of the nodules.

Sample C-7.

Total 0.15

C-10 Medium light gray (N-6) to light olive gray (5Y6/1) on fresh surface, weathered surfaces are slightly darker shades of these two colors, blocky to slightly platy, carbonaceous, fossiliferous, ferruginous claystone. Top covered.

Ironstone occurs as cylindrical concretions and/or nodules oriented with the long axis parallel to bedding. Sample of float collected.

Sample C-8; Washed residue:

Ammodiscus sp.	<1P
Bathysiphon sp.	8P
Lituotuba sp.	<1P
Productoid brachiopod (immature with attachment spines)	1
Glabrocingulum (*A.*) *grayvillensis* (internal mold)	1
High spired gastropod (internal mold)	1
Healdia sp. (broken)	1
Scolecodonts	2
?*Cavusgnathodus* sp.	1
?*Gnathodus* sp.	1
Hindeodellids (fragments)	<1P
Idiognathodus sp.	4
?*Streptognathodus* sp.	2

Section C--Continued

Bed	Description	Thickness (feet)
C-10--(Continued)		

Other conodonts (fragments)	<1P
Faecal pellets	10P
Mica flakes	2P

Total 4.15

C-11 Covered, probably claystone; abundant ferruginous, fine grained, well sorted sandstone float.

Total 11.5

C-12 Light olive gray (5Y5/2) to (5Y6/1) to greenish gray (5GY6/1) and grayish yellow green (5GY7/2) on fresh and weathered surfaces, blocky to slightly platy, "crumbly," slightly calcareous, (due to fossils) soft, slightly carbonaceous, ferruginous, fossiliferous claystone. Light brown (5YR5/6) to dark yellowish orange (10YR6/6) stains on bedding planes. Base covered.

Sample C-9; Washed residue:

Ammodiscus sp.	2P
Bathysiphon sp.	1P
Earlandinita sp.	3P
?Endothyra sp.	<1P
Endothyranella sp.	1P
Lituotuba sp.	1P
Inarticulate brachiopod fragments (?Lingula sp.)	<1P
Crurithyris planoconvexa (articulated, immature)	1P
?Plagioglypta sp. (broken fragments)	<1P
Anthraconeilo taffiana (articulated, immature)	<1P
Nuculopsis (P.) wewokana (articulated, immature)	<1P
Other pelecypods (unidentifiable, immature?)	<1P
Euphemites carbonarius (immature)	2
Glabrocingulum (A.) grayvillensis (various sizes)	4P
?Ianthinopsis sp. (immature)	<1P
Meekospira peracuta (immature)	<1P
Trepospira depressa (various sizes)	2P
Pseudorthoceras sp. (broken fragments)	<1P

Section C--Continued

Bed	Description	Thickness (feet)
C-12--(Continued)		

Crinoid debris (plates and columnals)	≪1P
Echinoid debris (spines)	<1P
Holothurian debris (sclerites)	1P
Ophiuroid and/or Asteroid debris (ossicles)	<1P
Scolecodonts	1
Gnathodus sp.	1
Fish debris	<1P
Faecal pellets	5P
Mica flakes	3P

Total 1.0

Note: Samples of float (fossils) were collected from the weathered exposures of beds 13 through and including 17.

C-13 Light olive gray (5Y5/2) to (5Y6/1) to greenish gray (5GY6/1) and grayish yellow green (5GY7/2) with mottled areas of medium light gray (N-6), grayish orange (10YR7/4) and dark yellowish orange (10YR6/6) on fresh surface; weathers slightly darker shades of above colors; blocky to "crumbly," soft, slightly calcareous (due to fossils), ferrugineous (ironstone), slightly carbonaceous (finely divided pieces), fossiliferous claystone. Contact with underlying bed (12) is gradational. Station C-796.2' is in this bed.

Ironstone concretions and/or nodules are generally small (+15 to 30 mm. max. dimension), light brown (5YR5/6) to moderate brown (5YR4/4) and moderately hard.

Sample C-10; Washed residue:

Ammobaculites sp.	1
Ammodiscus sp.	2P
Bathysiphon sp.	1P
Earlandinita sp.	3P
?Endothyra sp.	<1P
Endothyranella sp.	1P
Lituotuba sp.	1P
Lingula sp. (fragments)	<1P
Crurithyris planoconvexa (articulated, various sizes)	2P
Mesolobus decipiens (articulated, different sizes)	2

Section C--*Continued*

Bed	Description		Thickness (feet)
C-13--(*Continued*)			
	Unidentifiable brachiopods (fragments)	<1P	
	?*Plagioglypta* sp. (broken, fragments)	<1P	
	Anthraconeilo taffiana (articulated, various sizes)	<1P	
	Nuculopsis (*P.*) *anodontoides* (articulated, immature)	1	
	Nuculopsis (*P.*) *wewokana* (articulated, immature)	<1P	
	Polidevica bellistriata (articulated, various sizes)	3	
	Euphemites carbonarius	1	
	Glabrocingulum (*A.*) *grayvillensis* (various sizes)	6P	
	Ianthinopsis sp.	<1P	
	Meekospira peracuta (broken)	1P	
	Trepospira depressa (various sizes)	3P	
	Pseudorthocerus sp. (broken fragments)	<1P	
	?*Gonioloboceras* sp. (immature)	1	
	Unidentifiable ostracodes	<1P	
	Crinoid debris (columnals)	1P	
	Echinoid debris (spines, plates and jaw fragments)	1P	
	Holothurian debris (sclerites)	1P	
	Ophiuroid and/or Asteroid debris (ossicles)	<1P	
	?Scolecodonts (fragments)	2	
	Unidentifiable conodonts (fragments)	2	
	Fish debris	<1P	
	Faecal pellets	6P	
	Mica flakes	3P	
		Total	3.0
C-14	Light brown (5YR5/6) to dark yellowish orange (10YR6/6) on fresh surface, moderate brown (5YR3/4) to grayish brown (5YR3/2) weathered, hard, slightly calcareous, discontinuous, non-fossiliferous horizon of ironstone nodules and/or concretions.		
	Sample C-11; Acetate peel.		
		Total	0.1

Section C--Continued

Bed	Description	Thickness (feet)
C-15 (lower 0.9')	Light olive gray (5Y5/2) to (5Y6/1) to greenish gray (5GY6/1) and grayish yellow green (5GY7/2) with mottled areas of medium light gray (N-6) on fresh surface, weathered a medium gray (N-5) to darker shades of light olive gray, blocky, hard, slightly calcareous, ferruginous, fossiliferous claystone with traces of finely divided carbonaceous material.	
	Ironstone nodules and concretions are as described in bed C-13.	

Sample C-12; Washed residue:

Ammobaculites sp.	1
Ammodiscus sp.	3P
Bathysiphon sp.	1P
Earlandinita sp.	<1P
?*Endothyra* sp.	<1P
Endothyranella sp.	<1P
Globovalvulinids	1P
Reophax sp.	<1P
Tolypammina sp. (epizoan of larger invertebrates)	<1P
Inarticulate brachiopod fragments	<1P
Crurithyris planoconvexa (articulated, various sizes)	<1P
Plagioglypta sp.	<1P
Anthraconeilo taffiana (articulated, small)	1
Nuculopsis (*P.*) *wewokana* (articulated, immature)	1P
Polidevica bellistriata (articulated, immature)	<1P
Euphemites carbonarius (immature)	<1P
Glabrocingulum (*A.*) *grayvillensis* (various sizes)	5P
Meekospira peracuta (immature)	<1P
Trepospira depressa (various sizes)	1P
Pseudorthoceras sp. (broken fragments)	<1P
Goniatites (small)	<1P
?*Moorites* sp.	<1P
Crinoid debris (columnals)	<1P
Echinoid debris (spines)	1
Holothurian debris (sclerites)	<1P
Ophiuroid and/or Asteroid debris (ossicles)	<1P
?Scolecodonts (fragments)	<1P
Hindeodellids (fragments)	<1P
Idiognathodus sp.	<1P

Section C--Continued

Bed	Description		Thickness (feet)
C-15--(Continued)			
	Unidentifiable conodonts (fragments)	1	
	Faecal pellets	6P	
	Mica flakes	2P	
	Total		0.9
C-15 (upper 2.0')	Lithologically the same as the lower 0.9' of bed C-15.		
	Sample C-13; Washed residue:		
	Ammodiscus sp.	3P	
	Bathysiphon sp.	1P	
	Earlandinita sp.	<1P	
	?Endothyra sp.	<1P	
	Endothyranella sp.	<1P	
	?Globovalvulinids	1P	
	Reophax sp.	<1P	
	Tolypammina sp. (epizoan of bivalve shells)	<1P	
	?Inarticulate brachiopods (fragments)	<1P	
	Crurithyris planoconvexa (articulated, various sizes)	<1P	
	Plagioglypta sp. (broken fragments)	<1P	
	Anthraconeilo taffiana (articulated, small)	2	
	Nuculopsis (P.) wewokana (articulated, small)	1P	
	Polidevica bellistriata (articulated, various sizes)	<1P	
	Euphemites carbonarius (small)	1P	
	Glabrocingulum (A.) grayvillensis (various sizes)	7P	
	Meekospira peracuta (broken, various sizes)	<1P	
	Pseudozygopleurids	2P	
	Trepospira depressa (various sizes)	1P	
	Pseudorthoceras sp. (broken fragments)	<1P	
	Goniatites (small)	<1P	
	Moorites sp.	<1P	
	Hollinellid ostracodes	2P	
	Crinoid debris (columnals)	<1P	
	Echinoid debris (broken spines)	3P	
	Holothurian debris (sclerites)	<1P	
	Ophiuroid and/or Asteroid debris (ossicles)	<1P	
	?Scolecodonts (fragments)	<1P	
	Hindeodellids (fragments)	2P	
	Carbonaceous fragments (plants?)	<1P	
	Faecal pellets	5P	
	Mica flakes	2P	
	Total		2.0

Section C--Continued

Bed	Description	Thickness (feet)
C-16	Light brown (5YR5/6) to dark yellowish orange (10YR6/6) on fresh surface, moderate brown (5YR3/4) to grayish brown weathered, hard, slightly calcareous ironstone (siderite) nodules. All of these nodules are septaria with thin veins of white (N-9) calcite.	
	Sample C-13A; Acetate peel.	
	Total	0.1
C-17 (lower 3.0')	Lithologically the same as the lower 0.9' of bed C-15.	

Sample C-14; Washed residue:

Ammodiscus sp.	3P
Bathysiphon sp.	1P
Earlandinita sp.	<1P
Endothyranella sp.	<1P
Reophax sp.	<1P
Tolypammina sp. (epizoan on snails and crinoid columnals)	1P
?Inarticulate brachiopod (fragments)	<1P
Crurithyris planoconvexa (small, articulated)	<1P
Plagioglypta sp. (broken fragments)	<1P
Anthraconeilo taffiana (articulated)	2
Nuculopsis (P.) wewokana (articulated, small)	1P
Polidevica bellistriata (articulated, small)	<1P
Bellerophontid (broken)	1
Euphemites carbonarius (small)	<1P
Girtyspira sp.	<1P
Glabrocingulum (A.) grayvillensis (various sizes)	7P
Meekospira peracuta (broken, small)	<1P
Pseudozygopleurids	2P
Trepospira depressa (various sizes)	<1P
Pseudorthoceras sp. (broken fragments)	<1P
Goniatites (small)	<1P
?Bairdia sp. (articulated)	2
Amphissites sp. (articulated, small)	1
Trilobite fragment	1
Crinoid debris (columnals)	<1P
Echinoid debris (spines, Plates & pedicellaria)	10
Holothurian debris (sclerites)	<1P
Ophiuroid and/or Asteroid debris (ossicles)	3P
?Scolecodonts (fragments)	≪1P

Section C--Continued

Bed	Description		Thickness (feet)
C-17--(Continued)			
	Gnathodus sp.	1	
	Hindeodellids (fragments)	2	
	Streptognathodus sp.	1	
	Fish tooth?	1	
	Carbonaceous fragments (plants?)	≪1P	
	Faecal pellets	7P	
	Mica flakes	2P	
	Total		3.0
C-17 (next higher 2.0')	Lithologically the same as the lower 0.9' of bed C-15. Some of the ironstone nodules in this unit are septaria. This is the bed from which samples of Station C-803.7' were collected.		
	Sample C-15; Washed residue:		
	Ammodiscus sp.	2P	
	Bathysiphon sp.	1P	
	Earlandinita sp.	<1P	
	Endothyranella sp.	<1P	
	Reophax sp.	<1P	
	Tolypammina sp. (epizoan on snails and crinoid columnals)	1P	
	?Inarticulate brachiopod (fragments)	<1P	
	Lindstroemella cf. L. patula (articulated)	9	
	Crurithyris planoconvexa (articulated, various sizes)	1P	
	Plagioglypta sp. (broken fragments)	<1P	
	Anthraconeilo taffiana (articulated)	2	
	Nuculopsis girtyi (articulated)	2	
	Nuculopsis (P.) wewokana (articulated, small)	1P	
	Polidevica bellistriata (articulated, various sizes)	1P	
	Euphemites carbonarius (small)	<1P	
	Glabrocingulum (A.) grayvillensis (various sizes)	3P	
	Meekospira peracuta (broken, small)	<1P	
	Pseudozygopleurids	2P	
	Trepospira depressa (various sizes)	1P	
	Pseudorthoceras sp. (broken fragments)	<1P	
	Goniatites (small)	<1P	
	Metacoceras sp. (broken)	1	
	Healdia sp. (articulated)	1	
	Hollinellids (small, articulated)	1	

Section C--Continued

Bed	Description		Thickness (feet)
C-17--(Continued)			
	Crinoid debris (columnals)	<1P	
	Echinoid debris (spines, plates & pedicellaria)	10	
	Holothurian debris (sclerites)	<1P	
	Ophiuroid and/or Asteroid debris (ossicles)	3P	
	Faecal pellets	7P	
	Mica flakes	2P	
	Total		2.0
C-17 (next higher 3.0')	Lithologically the same as the lower 0.9' of bed C-15.		
	Sample C-16; Washed residue:		
	Ammobaculites sp.	1	
	Ammodiscus sp.	3P	
	Bathysiphon sp.	1P	
	Earlandinita sp.	<1P	
	Endothyra sp.	1	
	Reophax sp.	<1P	
	Tolypammina sp. (epizoan on snails and crinoid columnals)	1P	
	Lingula sp. (articulated)	1	
	Crurithyris planoconvexa (small, articulated)	<1P	
	Plagioglypta sp. (broken fragments)	<1P	
	Astartella cf. A. concentrica (fragments)	3	
	Anthraconeilo taffiana (articulated, various sizes)	2P	
	Nuculopsis girtyi (articulated)	2	
	Nuculopsis (P.) wewokana (small, articulated)	1P	
	Paleyoldia glabra (articulated)	1	
	Polidevica bellistriata (various sizes, articulated)	10	
	Euphemites carbonarius (various sizes)	<1P	
	Glabrocingulum (A.) grayvillensis (various sizes)	7P	
	Meekospira peracuta (broken, small)	<1P	
	Pseudozygopleurids	<1P	
	Trepospira depressa (various sizes)	1P	
	Pseudorthoceras sp. (broken fragments)	<1P	
	Goniatites (small)	<1P	
	Healdia sp. (articulated, various sizes)	1P	
	?Ulrichia sp. (small, articulated)	1	
	Crinoid debris (columnals)	<1P	
	Echinoid debris (spines, plates & pedicellaria)	10	

Section C--Continued

Bed	Description		Thickness (feet)
C-17--(Continued)			
	Holothurian debris (sclerites)	<1P	
	Ophiuroid and/or Asteroid debris (ossicles)	4P	
	Unidentifiable conodonts (fragments)	<1P	
	Faecal pellets	2P	
	Mica flakes	3P	
	Total		3.0
C-17 (upper	Lithologically the same as the lower 0.9' of bed C-15 except, this bed is more medium light gray (N-6) than it is light olive gray (5Y5/2) to (5Y6/1).		
	Sample C-17; Washed residue:		
	Ammobaculites sp.	1	
	Ammodiscus sp.	3P	
	Bathysiphon sp.	1P	
	Earlandinita sp.	<1P	
	Endothyranella sp.	<1P	
	Reophax sp.	<1P	
	Tolypammina sp. (epizoan on snails and crinoid columnals)	1P	
	Lingula sp. (articulated)	1	
	Crurithyris planoconvexa (small, articulated)	1P	
	Plagioglypta sp. (broken fragments)	<1P	
	Anthraconeilo taffiana (articulated, various sizes)	3P	
	Nuculopsis girtyi (articulated)	2	
	Nuculopsis (*P.*) *wewokana* (small, articulated)	1P	
	Polidevica bellistriata (articulated)	2	
	Euphemites carbonarius (small)	<1P	
	Glabrocingulum (*A.*) *grayvillensis* (various sizes)	10P	
	Meekospira peracuta (broken, small)	<1P	
	Pseudozygopleurids	2P	
	Trepospira depressa (various sizes)	3P	
	Pseudorthoceras sp. (broken fragments)	<1P	
	Gonioloboceras sp. (broken spec.)	1	
	Healdia sp. (articulated, various sizes)	1P	
	?*Ulrichia* sp. (articulated)	1	
	Crinoid debris (columnals)	<1P	
	Echinoid debris (spines, plates & pedicellaria)	10	
	Holothurian debris (sclerites)	<1P	
	Ophiuroid and/or Asteroid debris (ossicles)	4P	
	Unidentifiable conodonts (fragments)	<1P	

Section C--Continued

Bed	Description		Thickness (feet)
C-17--(Continued)			
	Faecal pellets	3P	
	Mica Flakes	2P	
	Total		3.0
C-18	Yellowish brown, clayey, "crumbly" soil. Contact with underlying bed (17) is gradational. No sample collected.		
	Total		3.5+
	TOTAL THICKNESS		49.7+

Section D

Starts at an elevation of 763.4', ±20.0' E. of C. of W. line of SW¼, NW¼, SE¼, NW¼, NW¼, Sec. 33, T. 7 N., R. 9 E., in stream bed and ends at an elevation of 775.7' just E. of C. of N. line of SW¼, NW¼, SE¼, NW¼, NW¼, Sec. 33, T. 7 N., R. 9 E., Hughes County, Oklahoma. In terms of the three reference points the top is: 1948.0' N.23°0'E. of point 1, 802.0' N.44°0'W. of point 2 and 732.0' N.50°0'W. of point 3; the base is: 1838.0' N.21°0'E. of point 1, 820.0' N.53°0'W. of point 2 and 751.0' N.59°15'W. of point 3.

Measured along the southeast side of the third large gully on the northeast side of the permanent stream, below (820.0' northwest of the center of) the W.P.A. Dam. Start at the mouth of the gully; measure (beds D-1 through the lower two-thirds of D-3) 8.0' vertically and 55.0' horizontally in a northwest direction; gully forks at this point; measure (remainder of beds) 4.3' vertically and 60.0' horizontally along the northeast branch to an elevation of 775.7'.

Bed	Description	Thickness (feet)
D-1	Medium gray (N-5) to medium dark gray (N-4) with stains and fossil molds of pale yellowish orange (10YR8/6), moderate yellow (5Y7/6), moderate brown (5YR4/4 and 5YR3/4), moderate yellowish brown	

Section D--Continued

Bed	Description	Thickness (feet)

D-1--(Continued)

(10YR5/4), grayish red (10R4/2) and dark reddish brown (10R3/4) and dark yellowish orange (10YR6/6) to light brown (5YR5/6) respectively on fresh surface, dark yellowish brown (10YR4/2) to moderate yellowish brown (10YR5/4) weathered, hard, fissile to platy, pyritic, fossiliferous shale.

Some "phosphatic" nodules of moderate size (10 to 15 mm. in diameter) occur with olive gray (5Y4/1) interiors and light olive gray (5Y6/1) exteriors.

Pyrite occurs as slender rods like those of bed-0, Sec. C; bed-3, Sec. B and bed 3, Sec. A. Some small selenite crystals are present around some of the fossil molds and along some bedding planes.

Sample D-1; Washed residue:

Bathysiphon sp.	1
Conularia cf. *C. crustula*	1
Lophophyllum sp.	1
Anthraconeilo taffiana (articulated, small)	1
Nuculopsis cf. *N. girtyi* (internal mold, articulated)	1
Meekospira peracuta (broken, internal mold)	1
Straparolus (A.) catilloides (partial internal molds)	3
Hindeodellids (fragments)	1
Unidentifiable conodonts (fragments)	1
Faecal pellets	<1P

Total 2.8

D-2 Grayish black (N-2) to medium gray (N-4) on fresh surface, olive gray (5Y4/1) to light olive gray (5Y6/1) and dark yellowish brown (10YR4/2) and moderate brown (5YR4/4) weathered, hard, highly argillaceous, discontinuous, dense, fine grained, slightly pyritic, non-fossiliferous calcisiltite to carbonate mudstone nodules.

Pyrite occurs as circular to irregular elongate masses in cross section suggesting burrow fillings.

Section D--Continued

Bed	Description	Thickness (feet)

D-2--(Continued)

Gypsum crystals coat parts of some of the nodules.

Sample D-1; Acetate peel.

Total 0.2

D-3 (lower 1.0')

Light gray (N-7) and medium light gray (N-6) mottled with medium gray (N-5) and medium dark gray (N-4), platy to fissile shale interbedded and interlaminated with moderate yellowish brown (10YR5/4) and grayish orange (10YR7/4), fissile to platy, slightly blocky claystone. Some dark reddish brown (10R3/4) stains on some of the bedding planes.

Numerous small, more or less straight circular holes, generally perpendicular to bedding. Some are lined with iron oxide and others with a dark (pyritic?) material. The mottled areas often have these holes in the center. Suggests that these were once iron sulfide rods that have been oxidized. The two lithologies each constitute more or less 50% of the bed. Similar to bed 8 of Sections A and B. Some dark yellowish orange (10YR6/6) to light brown (5YR5/6) stains on some bedding planes.

Sample D-2; Washed residue:

Bathysiphon sp.	2P
Lituotuba sp.	1P
Reophax sp.	<1P
Lingula sp. (articulated, internal mold)	1
Anthraconeilo taffiana (internal mold, articulated)	1
Unidentifiable pelecypod (internal mold, articulated)	1
Trepospira depressa (internal mold)	2
Unidentifiable coiled cephalopod (partial internal mold)	1
Scolecodonts	1
Cavusgnathodus sp.	1
Gnathodus sp.	3
Hindeodellids (fragments)	15
Idiognathodus sp.	3
Streptognathodus sp.	1
Unidentifiable conodonts (fragments)	<1P
Faecal pellets	5P

Total 1.0

Section D--Continued

Bed	Description		Thickness
D-3 (upper 6.5')	Lithologically the same as lower 1.0' of bed D-3 but the shale lithology only constitutes 30% of the total while claystone is 70%.		
	Sample D-3; Washed residue:		
	Ammodiscus sp.	2P	
	Bathysiphon sp.	1P	
	Lituotuba sp.	<1P	
	Reophax sp.	<1P	
	Faecal pellets	2P	
	Total		6.5
D-4	Light brown (5YR5/6) to dark yellowish orange (10YR6/6) on fresh surface, grayish orange (10YR7/4) to pale brown (5YR5/2) and dull dusky yellowish brown (10YR2/2) weathered, moderately hard, non-fossiliferous, very slightly calcareous, discontinuous horizon of ironstone nodules.		
	Sample D-4.		
	Total		0.1
D-5	Mottled light gray (N-7) to medium light gray (N-6) and yellowish gray (5Y7/2), pale yellowish brown (10YR6/2) and grayish orange (10YR7/4) on both fresh and weathered surfaces, blocky to platy, "crumbly," fossiliferous claystone. Some stained areas of dark yellowish orange (10YR6/6) and light brown (5YR5/6).		
	Sample D-5; Washed residue:		
	Ammodiscus sp.	1P	
	Bathysiphon sp.	<1P	
	Lituotuba sp.	<1P	
	Anthraconeilo taffiana (internal mold, articulated)	1	
	Unidentifiable conodonts (fragments)	2	
	Quartz grains, round to subangular, fine to very fine sand size	10P	
	Total		0.7

Section D--Continued

Bed	Description	Thickness (feet)
D-6	Yellowish brown clayey, "crumbly" soil. No sample collected.	
	Total	1.0+
	TOTAL THICKNESS	12.3+

Section E

Starts at an elevation of 763.0' ±10.0'W. of C. of E. line of E.½,NW¼, SE¼, NE¼, SW¼, NW¼, NW¼, Sec. 33. T. 7 N., R. 9 E., in a pit dug in the floor of a gully and proceeds N-NE up the gully to a glade, over the top of the glade to a sandstone exposure along an old road at an elevation of 891.3', near C. of W.½, SE¼, SE¼, NE¼, NW¼, NE¼, NW¼, NW¼, Sec. 33, T. 7 N., R. 9 E., Hughes County, Oklahoma. In terms of the three reference points the top is: 2671.0' N.20°30'E. of point 1, 1326.0' N.16°0'W. of point 2 and 1227.0' of N.17°30'W. of point 3; the base is: 1854.0' N.17°30'E. of point 1, 927.0' N.54°0'W. of point 2, and 870.0' N.59°30'W. of point 3.

Measured in the fourth large gully (northwest side of lower gully and northeast side of upper gully) on the northeast side of the permanent stream, below (927.0' northwest of the center of), the W.P.A. dam and the west side and center of a glade. Start near mouth of gully; measure (beds E-1 through the lower half of E-10) 9.15' vertically and 130.0' horizontally in a northeast direction; then measure (beds E-10, upper half, through E-14) 7.15' vertically and 60.0' horizontally in a northwest direction; along (northeast) temporary stream bed in a grazed wooded area (beds E-15 through E-19) 23.0' vertically and 330.0' horizontally to where gully branches; follow west fork 180.0' horizontally in a nearly due north direction (beds E-20 through the lower 4.0' of E-22) to the floor and lower slopes of the glade (bed E-22, upper 10.0'), a total of 22.0' vertically; offset 50.0' N.78°30'E.; measure (beds E-23 through E-25, upper slopes of glade) 26.0' vertically and 60.0' horizontally N.25°0'E.; proceed 28.0' vertically and 96.9' horizontally N.35°0'E. (bed E-26) to a gully which trends N.65°0'E.; measure (remainder of beds) 13.0' vertically and 57.14' horizontally up this gully to an old road (which trends approximately north-south, and separates beds E-29 and E-30) at an elevation of 891.3'.

Section E

Bed	Description		Thickness (feet)
E-1	Medium gray (N-5) to medium dark gray (N-4) on fresh surface, lighter shades of these colors weathered, fissile to slightly platy, very hard, pyritic, fossiliferous, possibly carbonaceous shale. Similar to bed 3 of Sections A and B.		
	Sample E-1; Washed residue:		
	Bathysiphon sp.	2	
	Reophax sp.	<1P	
	Pseudorthoceras sp. (pyritized chamber)	1	
	Scolecodonts	1	
	Idiognathodus sp.	1	
	Unidentifiable conodonts (fragments)	1	
	Faecal pellets	<1P	
		Total	0.2
E-2	Grayish black (N-2) to medium gray (N-5) on fresh surface, medium gray (N-5) to medium dark gray (N-4), weathered, highly argillaceous, pyritic, non-fossiliferous, carbonaceous, discontinuous horizon of calcisiltite to carbonate mudstone nodules. Shape of pyrite masses suggests burrowing. Similar to bed 4 of Sections A and B.		
	Sample E-2, Acetate peel.		
		Total	0.2
E-3	Lithologically the same as bed E-1 except more stains of dark reddish brown (10R3/4), grayish red (10R4/2), grayish brown (5YR3/2), dusky brown (5YR2/2), light brown (5YR5/6) and dark yellowish orange (10YR6/6) on the bedding planes and non-fossiliferous.		
	Pyrite rods oriented at random with respect to the bedding are heavily oxidized.		
	Sample E-3; Washed residue:		
	Faecal pellets	1P	
	Pyritic debris	1P	
		Total	0.2

Section E--*Continued*

Bed	Description	Thickness (feet)

E-4

Medium dark gray (N-4) fresh, medium gray (N-5), to medium light gray (N-6) weathered, platy, hard, pyritic, fossiliferous, carbonaceous shale. Contact with underlying bed (E-3) is gradational.

Pyrite occurs as very small grains more or less evenly distributed throughout this bed. Some selenite crystals (small) occur along the bedding planes.

Sample E-4; Washed residue:

Bathysiphon sp.	2
Earlandinita sp.	1
Conularia cf. *C. crustula*	1
Lindstroemella cf. *L. patula*	3
Scolecodonts	1
Fish debris	5
Faecal pellets	1P

Total 2.4

E-5

Lithologically the same as bed E-2. Etched surface of one nodule contained the longitudinal section of a snail, probably *Meekospira* sp.

Sample E-5; Acetate peel.

Total 0.2

E-6

Dark gray (N-3), fresh, medium gray (N-5) weathered, fissile to platy, slightly blocky in part, pyritic, carbonaceous shale. Stained as in bed E-3 below.

Pyrite occurs as slender rods, irregular masses and minute bodies which resemble sponge spicules in size and shape. Some small selenite crystals occur on the bedding planes.

Sample E-6; Washed residue:

Faecal pellets	<1P
Pyritic debris	1P

Total 1.3

Note: Separating bed E-6 from E-7 is a one specimen thick horizon of the gastropod *Straparolus* (*Amphiscapha*) *catilloides*. Six specimens of this snail were collected along with two productoid brachiopods (very poorly preserved) and one piece of pyritized wood.

Section E--Continued

Bed	Description		Thickness (feet)
E-7 (lower 1.0')	Medium gray (N-5) to medium dark gray (N-4) fresh, lighter shades of these colors weathered, fissile to platy, very brittle, pyritic, fossiliferous, carbonaceous shale with abundant stains of light brown (5YR5/6), dark yellowish orange (10YR6/6), grayish yellow (5Y8/4), grayish brown (5YR3/2) and light olive gray (5Y6/1) on the bedding planes. A few small selenite crystals occur on some bedding planes.		
	Sample E-8; Washed residue:		
	Ammodiscus sp.	6	
	Bathysiphon sp.	7	
	Globovalvulinids?	2	
	Lindstroemella cf. L. patula	2	
	Scolecodonts	1	
	Faecal pellets	<1P	
	Pyritic debris	1P	
	Total		1.0
E-7 (middle 1.5')	Medium gray (N-5) to medium dark (N-4) mottled with light olive gray (5Y6/1) and yellowish gray (5Y7/2) fresh, light gray (N-7) to medium light gray (N-6) weathered, platy to fissile, fossiliferous, clayey? shale. Staining on bedding planes as noted in lower 1.0' of this bed (E-7).		
	Sample E-9; Washed residue:		
	Ammodiscus sp.	9	
	Bathysiphon sp.	4	
	Lindstroemella cf. L. patula	1	
	Scolecodonts	1	
	Faecal pellets	<1P	
	Pyritic debris	1P	
	Total		1.5

Note: At this elevation, separating bed E-7, is a horizon of highly weathered very fine grained (crystalline?) "phosphatic" nodules. They are light olive gray (5Y6/1) to (5Y5/2) fresh and dusky yellow (5Y6/4) to pale yellowish brown (10YR6/2) weathered.

Sample E-9A.

Section E--Continued

Bed	Description	Thickness (feet)
E-7--(Continued) (upper 1.0')	Lithologically the same as the middle 1.5' of bed E-7 except that it contains numerous "phasphatic" type nodules. Nodule size is from 1x2 mm. to 3x4 mm. They have medium dark gray (N-4) centers which grade outwards to lighter grays and olive gray.	

Sample E-10; Washed residue:

Anthraconeilo taffiana (internal mold, articulated)	1	
Pyritic debris	<1P	
Total		1.0

E-8	Medium gray (N-5) to medium dark gray (N-4), platy, carbonaceous, fossiliferous, slightly micaceous, shale interlaminated with light gray (N-7) to medium light gray (N-6) and light olive gray (5Y6/1) to (5Y5/2), dark yellowish orange (10YR6/6) and grayish orange (10YR7/4), blocky, micaceous, carbonaceous, fossiliferous claystone. Some small selenite crystals occur along bedding planes. Contact with underlying bed (E-7) is gradational.	

Sample E-11; Washed residue:

Ammodiscus sp.	2P	
Bathysiphon sp.	3P	
Reophax sp.	7	
Meekospira peracuta (internal mold, immature)	1	
Faecal pellets (various sizes)	8P	
Gypsum (small crystals and aggregates)	30P	
Total		0.3

E-9	Medium light gray (N-6) to light olive gray (5Y6/1) fresh, dark yellowish orange (10YR6/6) to light brown (5YR5/6) weathered, soft, discontinuous, undulating, calcareous concentric layered ironstone nodules (concretions) Pseudorthoceras sp. is embedded in one of these concretions. Interiors are hard and often contain thin "hair-like" veins of calcite.	

Sample E-12; Acetate peel.

Total	0.2

Section E--Continued

Bed	Description	Thickness (feet)
E-10	Lithologically the same as bed E-8 below, an interlamination of claystone and shale with more claystone than shale, in terms of percentages it is approximately 65 to 35 respectively.	

Sample E-13; Washed residue:

Ammodiscus sp.	3P
Bathysiphon sp.	1P
Reophax sp.	5
Unidentifiable pelecypod (internal mold)	1
Unidentifiable gastropods (partial internal molds)	2
Scolecodonts	4
Idiognathodus sp. (fragment)	1
Unidentifiable conodonts (fragments)	2
Faecal pellets	8P
Gypsum (small crystals and aggregates)	30P

Total 1.3

E-11 Medium light gray (N-6) to medium gray (N-5) fresh, grayish orange (10YR7/4) and shades of dark yellowish orange (10YR6/6) weathered, soft, non-calcareous exterior; hard, calcareous interior; slightly pyritic; carbonaceous?; highly argillaceous; badly weathered calcisiltite or carbonate mudstone? nodule horizon. May be ironstone (sideritic) nodules. Exterior is often coated with selenite crystals. Appears to be more or less continuous at this locality.

Sample E-14; Acetate peel.

Total 0.1

E-12 Lithologically this is the same as bed E-8 except there is more of the claystone lithology. Percentage here is more like 80% claystone and 20% shale.

Sample E-15; Washed residue:

Ammodiscus sp.	<1P
Bathysiphon sp.	5P
Reophax sp.	<1P
Scolecodonts	1
Hindeodellids (fragments)	10

Section E--Continued

Bed	Description		Thickness (feet)
E-12--(Continued)			
	Idiognathodus sp.	1	
	?*Streptognathodus* sp.	3	
	Unidentifiable conodonts (fragments)	4	
	Fish debris	1	
	Faecal pellets	7P	
	Gypsum (small crystals and aggregates)	35P	
	Total		4.8
E-13	Dark yellowish orange (10YR6/6) to light brown (5YR5/6), very soft, very slightly calcareous, discontinuous ironstone nodule and/or concretion horizon. May have originally been siderite or ferruginous carbonate mudstone.		
	Sample E-16.		
	Total		0.1
E-14	Light olive gray (5Y6/1) to grayish orange (10YR7/4) to light gray (N-7) and medium light gray (N-6) fresh, slightly lighter shades of these colors weathered, blocky to slightly platy, rare carbonaceous fragments, highly oxidized pyritic rods, fossiliferous claystone. Small ironstone nodules and stains of light brown (5YR5/6) to dark yellowish orange (10YR6/6) are quite common. Top covered.		
	Samples E-17 and E-17A; Washed residues:		
	Ammodiscus sp.	1P	
	Bathysiphon sp.	5P	
	Reophax sp.	<1P	
	Mesolobus sp. (broken internal mold)	1	
	Anthraconeilo taffiana (immature)	1	
	Glabrocingulum (*A.*) *grayvillensis* (various sizes)	4	
	Ianthinopsis sp. (internal mold)	1	
	Meekospira peracuta (broken)	1	
	Trepospira depressa (partial internal mold)	1	
	Coiled molluscan (very small)	1	
	Healdia sp. (articulated)	1	
	Unidentifiable ostracodes	2	
	Crinoid debris (columnals)	2	
	Echinoid debris	2	

Section E--Continued

Bed	Description	Thickness (feet)

E-14--(Continued)

Scolecodonts (fragments)	<1P	
Gnathodus sp. (fragment)	1	
Hindeodellids (fragments)	8	
Idiognathodus sp.	1	
Streptognathodus sp.	1	
Unidentifiable conodonts	5	
Faecal pellets	5P	
	Total	1.5

E-15 Covered, probably claystone. Three float samples collected: one of lower 5.0' (E-18), one of middle 5.0' (E-19), and one of upper 2.5' of E-15 and lower 2.5' of E-16 (E-20).

Total 12.5

E-16 Light olive gray (5Y6/1) with light gray (N-7) mottling fresh, lighter shades of same colors weathered, soft, blocky, ferrugineous, fossiliferous very slightly calcareous, micaceous and carbonaceous claystone. Contains light brown (5YR5/6) to dark yellowish orange (10YR6/6), hard, calcareous small ironstone nodules and septaria. Sample E-21 of float collected from upper 2.5' of this bed. This is the bed from which samples of Station E-793.0' were collected. Base and top covered.

Sample E-20A; Washed residue:

Ammobaculites sp.	1P
Ammodiscus sp.	2P
Bathysiphon sp.	<1P
Earlandinita sp.	1P
Endothyranella sp.	<1P
Lituotuba sp.	1P
Reophax sp.	<1P
Crurithyris planoconvexa (articulated, various sizes)	2P
Mesolobus sp. (1 articulated, 3 fragments, all small)	4
Nudirostra rockymontanum (articulated)	1
Plagioglypta sp. (broken specimens)	5
Anthraconeilo taffiana (articulated, various sizes)	4P

Section E--Continued

Bed	Description	Thickness (feet)

E-16--(Continued)

Nuculopsis girtyi (articulated)	1
Nuculopsis (P.) anodontoides (articulated)	2
Nuculopsis (P.) wewokana (articulated)	2
Paleyoldia glabra (articulated)	2
Polidevica bellistriata (articulated, various sizes)	3
Euphemites carbonarius (various sizes)	<1P
Glabrocingulum (A.) grayvillensis (various sizes)	5P
Ianthinopsis sp.	<1P
Meekospira peracuta (broken)	1P
Trepospira depressa (various sizes)	3P
Goniatites (small)	10
Amphissites sp. (articulated)	1
Healdia sp. (articulated)	1
Crinoid debris (columnal)	1
Echinoid debris (spines & pedicellaria)	2
Holothurian debris (sclerites)	<1P
Ophiuroid and/or Asteroid debris (ossicles)	3
Scolecodonts (fragments)	≪1P
Unidentifiable conodonts	1
Faecal pellets	10P
Gypsum (small crystals)	5P

Total 5.0

E-17 Covered, probably claystone.

Total 0.5

E-18 Lithologically the same as bed E-16 except that the claystone appears to be slightly more calcareous. Sample E-22 of float collected from beds E-17 and E-18. Base and top covered.

Sample E-22A; Washed residue:

Ammobaculites sp.	1P
Ammodiscus sp.	2P
Bathysiphon sp.	<1P
Earlandinita sp.	1P
Endothyranella sp.	<1P
Lituotuba sp.	1P
Reophax sp.	<1P

Section E--Continued

Bed	Description	Thickness (feet)
E-18--(Continued)		

Lingula cf. L. carbonaria (articulated)	1
Cleiothyridina orbicularis (articulated, immature)	1
Crurithyris planoconvexa (articulated, various sizes)	2P
Nudirostra rockmontanum	1
Plagioglypta sp. (broken spec.)	1P
Anthraconeilo taffiana (articulated, various sizes)	4P
Nuculopsis girtyi (articulated)	1
Nuculopsis (P.) anodontoides (articulated)	2
Nuculopsis (P.) wewokana (articulated)	2
Polidevica bellistriata (articulated, various sizes)	6
Euphemites carbonarius (various sizes)	<1P
Glabrocingulum (A.) grayvillensis (various sizes)	5P
Ianthinopsis sp.	<1P
Meekospira peracuta (broken)	2
Pseudozygopleurids	2
Trepospira depressa (various sizes)	3P
Pseudorthoceras sp. (broken spec.)	1
Goniatites (small)	9
Healdia sp.	1P
Crinoid debris (columnals & plates)	1P
Echinoid debris (plates, spines and pedicellaria)	<1P
Holothurian debris (sclerites)	<1P
Ophiuroid and/or Asteroid debris (ossicles)	1P
Scolecodonts (fragments)	≪1P
Faecal pellets	10P
Gypsum (small crystals)	4P

Total 2.0

E-19 Covered, claystone. Samples of Station E-800.5' were dug from this covered interval. Claystone is lithologically as bed E-16 below, slightly more calcareous. Sample E-23 of float collected from this bed and the lower 2.0' of bed E-20.

Total 3.0

Section E--Continued

Bed	Description	Thickness (feet)
E-20 (lower 2.0')	Light olive gray (5Y6/1) mottled with some light gray (N-7) fresh, lighter shades of same colors weathered, soft, blocky, slightly calcareous, micaceous, carbonaceous?, fossiliferous claystone. Contains ironstone nodules as described in bed E-16 below. Base covered.	

Sample E-23A, Washed residue:

Ammobaculites sp.	1
Ammodiscus sp.	4P
Bathysiphon sp.	5P
Earlandinita sp.	3P
Endothyranella sp.	2P
Reophax sp.	1P
Plagioglypta sp. (broken specimens)	1P
Anthraconeilo taffiana (immature, articulated)	3P
Astartella cf. A. caoncentrica (articulated)	1
Nuculopsis (P.) wewokana (immature, articulated)	2P
Euphemites carbonarius (small)	2
Glabrocingulum (A.) grayvillensis (various sizes)	5P
Trepospira depressa	1
Goniatites (small)	1
Amphissites sp. (disarticulated)	1
Crinoid debris (columnals, plates and spines)	1P
Echinoid debris (spines & pedicellaria)	<1P
Holothurian debris (sclerites)	2P
Ophiuroid and/or Asteroid debris (ossicles)	3P
?Scolecondonts (fragments)	<<1P
Hindeodellids (fragments)	2
Faecal pellets	8P

Total 2.0

Bed	Description	Thickness (feet)
E-20 (middle 3.0')	Lithologically the same as the lower 2.0' of bed E-20.	

Sample E-24A; Washed residue:

Ammodiscus sp.	4P
Bathysiphon sp.	2P
Endothyranella sp.	1P
Lituotuba sp.	1P
Reophax sp. (with micaceous tests)	2P
Crurithyris planoconvexa (articulated, immature)	2

Section E--Continued

Bed	Description		Thickness (feet)
E-20--(Continued)			
	Plagioglypta sp. (broken fragments)	1P	
	Anthraconeilo taffiana (articulated, immature)	5P	
	Astartella cf. A. concentrica (open but still articulated)	1	
	Nuculopsis girtyi (articulated)	2	
	Nuculopsis (P.) wewokana (articulated, immature)	<1P	
	Paleyoldia glabra (articulated)	1	
	Polidevica bellistriata (articulated, various sizes)	8	
	?Schizodus sp. (articulated)	1	
	Bellerophon (Pharkidenotus) percarinatus	1	
	Euphemites carbonarius (various sizes)	1P	
	Girtyspira sp.	1	
	Glabrocingulum (A.) grayvillensis (various sizes)	12P	
	Ianthinopsis sp. (small)	1P	
	Meekospira peracuta (various sizes, broken)	5	
	Pseudozygopleurids	1	
	Trepospira depressa	4P	
	Goniatites (?Gastrioceras sp.) (small)	<1P	
	Amphissites sp. (articulated)	1	
	Crinoid debris (columnals, plates and spines)	2P	
	Echinoid debris (spines, plates & pedicellaria)	<1P	
	Holothurian debris (sclerites)	1P	
	Ophiuroids and/or Asteroid debris (ossicles)	4P	
	Scolecodonts (including fragments)	1P	
	?Gnathodus sp.	1	
	Hindeodellids (fragments)	1	
	Idiognathodus sp.	1	
	?Streptognathodus sp.	1	
	Faecal pellets	7P	
	Gypsum crystals (small)	1P	
	Total		3.0
E-20 (upper 3.0').	Lithologically the same as the lower 2.0' of bed E-20. Sample E-24 of float collected from the middle 3.0' and upper 3.0' of this bed (E-20).		
	Sample E-24B; Washed residue:		
	Ammodiscus sp.	4P	
	Bathysiphon sp.	2P	

Bed	Description		Thickness (feet)
E-20--(Continued)			
	Endothyranella sp.	1P	
	Lituotuba sp.	1P	
	Reophax sp. (with micaceous tests)	2P	
	Crurithyris planoconvexa (articulated)	1	
	Plagioglypta sp. (broken specimens)	<1P	
	Anthraconeilo taffiana (articulated, various sizes)	3P	
	Nuculopsis (P.) wewokana (articulated, immature)	<1P	
	Polidevica bellistriata (1 articulated and 1 left valve)	2	
	Schizodus sp. (articulated)	1	
	Euphemites carbonarius (various sizes)	1P	
	Glabrocingulum (A.) grayvillensis	9P	
	Ianthinopsis sp. (small)	1P	
	Trepospira depressa	2P	
	Goniatites (small)	<1P	
	Amphissites sp. (articulated)	1	
	Crinoid debris (columnals, plates and spines)	2P	
	Echinoid debris (spines, plates and pedicellaria)	5P	
	Holothurian debris (sclerites)	<1P	
	Ophiuroids and/or Asteroid debris (ossicles)	4P	
	?Scolecodonts (fragments)	≪1P	
	Hindeodellids (fragments)	≪1P	
	Faecal pellets	8P	
	Gypsum crystals (small)	1P	
		Total	3.0

E-21 Medium gray (N-5) to medium dark gray (N-4) fresh, dark yellowish orange (10YR6/6) to light brown (5YR5/6) weathered, hard, slightly argillaceous, pyritic, nonfossiliferous nodules of carbonate mudstone.

Sample E-25A (in part); Acetate peel.

Total 0.1

E-22 (lower 4.0') Greenish gray (5GY6/1) to yellowish gray (5Y7/2) and light olive gray (5Y6/1) fresh, slightly lighter shades of these colors weathered, soft, blocky, slightly, calcareous, carbonaceous, micaceous, fossiliferous claystone with ironstone nodules and/or concretions as described in bed E-16. Float sample E-25 collected from this interval.

Section E--Continued

Bed	Description	Thickness

E-22--(Continued)

Abundant "limonitic" fossils occur in the upper 3.0' of this bed. These include clams, gastropods and orbiculoids. One specimen, Polidevica bellistriata, of pelecypod is in what appears to be lift position (Stanley, 1968).

Sample E-25B; Washed residue:

Ammodiscus sp.	2P
Bathysiphon sp.	1P
Earlandinita sp.	1
Lituotuba sp.	1P
Reophax sp.	<1P
Lindstroemella cf. L. patula (various sizes)	5
Plagioglypta sp. (broken specimens)	<1P
Anthraconeilo taffiana (articulated small)	1P
Astartella cf. A. concentrica (articulated, small)	1
Nuculopsis girtyi (2 articulated, 1 right valve)	3
Nuculopsis (P.) wewokana (articulated, immature)	1P
Paleyoldia glabra (articulated, internal mold)	1
Polidevica bellistriata (articulated, internal mold)	1
Euphemites carbonarius (small)	1P
Glabrocingulum (A.) grayvillensis	5P
Ianthinopsis sp. (small)	<1P
Meekospira peracuta (broken, immature)	<1P
Pseudozygopleurids	2
Trepospira depressa (various sizes)	1P
Goniatites (fragments and small specimens)	≪1P
Amphissites sp. (articulated)	1
Unidentified ostracodes (articulated)	<1P
Crinoid debris (columnals, splates and spines)	<1P
Echinoid debris (spines, plates, pedicellaria)	<1P
Ophiuroid and/or Asteroid debris (ossicles)	3P
Scolecodonts (4 specimens and fragments)	<1P
Hindeodellids (fragment)	1
Unidentifiable conodonts (fragment)	1
Fish debris (teeth?, scales?, etc.)	3
Faecal pellets	9P
Carbonaceous material	<1P
Gypsum crystals (small)	<1P

Total 4.0

Section E--Continued

Bed	Description	Thickness (feet)
E-22 (upper 10.0')	Lithologically the same as the lower 4.0' of bed E-22 but mottled with light grays and faint bluish hues particularly in the upper part. This mottling effect gradually increases upwards in this interval. There are also some small irregular calcareous nodules about the size and shape of peanuts in the upper foot or two of this bed. Float sample E-26 collected from this interval. This is the interval which composes the floor and lower slopes of the glade at this section.	

Sample E-26A; Washed residue:

Ammodiscus sp.	3P
Bathysiphon sp.	2P
Earlandinita sp.	2P
Lituotuba sp.	1P
Reophax sp.	1P
Ramose bryozoans (fragment of colony)	1
Lingula cf. L. carbonaria (articulated)	1
Crurithyris planoconvexa (articulated)	2
Plagioglypta sp. (broken specimens)	<1P
Anthraconeilo taffiana (articulated various sizes)	2P
Nuculopsis (P.) wewokana (articulated, immature)	1P
Polidevica bellistriata (articulated)	2
Glabrocingulum (A.) grayvillensis (various sizes)	1P
Ianthinopsis sp.	<1P
Meekospira peracuta (immature)	<1P
Pseudozygopleurids	1
Straparolus (Amphiscapha) catilloides	1
Gastrioceras cf. G. venatum	1
Bairdia sp. (articulated)	1
Healdia sp. (articulated)	1
Unidentified ostracodes (articulated)	2P
Crinoid debris (columnals, plates and spines)	2P
Holothurian debris (sclerites)	<1P
Ophiuroid and/or Asteroid debris	1P
Scolecodonts (fragments)	<<1P
Hindeodellids (fragment)	1
Streptognathodus sp.	2
Faecal pellets	10P

Total 10.0

E-23 Claystone as below (upper 10.0' of bed E-22), mostly all grayish and faint bluish, calcareous claystone with

Bed	Description	Thickness (feet)

E-23--(Continued)

calcareous nodules. Ironstone nodules are lacking as is carbonaceous material. Float sample E-27 was collected from this interval. This is the bed from which samples of Stations E-826.0' and E-827.2' were collected. Contact with underlying bed (E-22) is gradational.

Sample E-27A; Washed residue:

Ammodiscus sp.	4P
Bathysiphon sp.	2P
Earlandinita sp.	5P
Lituotuba sp.	<1P
Tolypammina sp. (encrusting all the larger invertebrates, brachiopods, pelecypods & gastropods)	10P
Ramose bryozoans (fragment of colony)	7
Cleiothyridina orbicularis (articulated, various sizes)	2P
Crurithyris planoconvexa (articulated, and disarticulated, various sizes)	2P
Mesolobus euampygus (articulated and disarticulated, various sizes)	1P
Plagioglypta sp. (broken specimen)	1
Anthraconeilo taffiana (articulated, various sizes)	1
Astartella cf. A. concentrica (right valves, broken)	3
Nuculopsis (P.) wewokana (articulated, various sizes)	2P
?Parallelodon sp. (articulated)	1
Polidevica bellistriata (articulated)	2
Glabrocingulum (A.) grayvillensis (various sizes)	<1P
Ianthinopsis sp. (small)	1P
Meekospira peracuta (various sizes)	1P
Pseudozygopleurids	<1P
Straparolus (A.) catilloides (various sizes)	<1P
Trepospira depressa	1
Pseudorthoceras sp. (broken specimen)	3
Trilobite debris (genal spines, thoracic segments, etc.)	1P
Amphissites sp. (various sizes, 50% articulated)	<1P
Bairdia sp. (various sizes, 50% articulated)	1P
Cavellina sp. (various sizes, 50% articulated)	1P
Healdia sp. (various sizes, 50% articulated)	2P
Crinoid debris (plates, columnals & spines)	3P
Echinoid debris (plates and spines)	2P

Section E--Continued

Bed	Description		Thickness (feet)
E-23--(Continued)			
	Holothurian debris (sclerites)	1P	
	Ophiuroid and/or Asteroid debris (ossicles)	<1P	
	?Scolecodont fragments	Trace	
	Gnathodus sp.	1	
	Ozarkodina sp.	1	
	Unidentifiable shell debris	10P	
		Total	5.0
E-24	Claystone as below (bed E-23). Float sample E-28 collected from this interval. Contact with underlying bed (E-23) is gradational and arbitrarily placed.		
	Sample E-28A; Washed residue:		
	Ammodiscus sp.	4P	
	Bathysiphon sp.	2P	
	Earlandinita sp.	5P	
	?Fusilina sp.	1	
	Lituotuba sp.	<1P	
	Tolypammina sp. (encrusting all the larger invertebrates, brachiopods, pelecypods, and gastropods)	10P	
	Prismopora sp. (fragments of colony)	1	
	Ramose bryozoans (fragments of colony)	1	
	Cleiothyridina orbicularis (articulated, various sizes)	2P	
	Crurithyris planoconvexa (articulated and disarticulated, various sizes)	2P	
	Mesolobus decipiens (disarticulated, various sizes)	1P	
	Mesolobus euampygus (articulated and disarticulated, various sizes)	2P	
	Plagioglypta sp. (broken specimen)	1	
	Anthraconeilo taffiana (articulated, various sizes)	1	
	Nuculopsis (P.) wewokana (articulated, various sizes)	2P	
	Polidevica bellistriata (articulated)	2	
	Bellerophon sp. (internal mold)	1	
	Euphemites carbonarius (immature)	<1P	
	Glabrocingulum (A.) grayvillensis (various sizes)	<1P	
	Ianthinopsis sp. (small)	1P	
	Meekospira peracuta (various sizes)	1P	
	Pseudozygopleurids	<1P	

Section E--Continued

Bed	Description		Thickness (feet)
E-24--(Continued)			
	Straparolus (A.) catilloides (various sizes)	1P	
	Trepospira depressa	1	
	Trilobite debris (genal spines, thoracic segments, etc.)	1P	
	Amphissites sp. (various sizes, 50% articulated)	<1P	
	Bairdia sp. (various sizes, 50% articulated)	1P	
	Cavellina sp. (various sizes, 50% articulated)	1P	
	Healdia sp. (various sizes, 50% articulated)	2P	
	Crinoid debris (plates, columnals, and spines)	2P	
	Echinoid debris (sclerites)	2P	
	Ophiuroid and/or Asteroid debris (ossicles)	1P	
	?Scolecodont fragments	Trace	
	Ozarkodina sp.	1	
	Unidentifiable shell debris	10P	
	Fish debris (scale?)	1	
		Total	5.0
E-25 (lower 5.0')	Claystone as below at bed E-24 but less calcareous. Ironstone nodules are present as described in bed E-16 but in this lower unit are less abundant than higher up. Samples of Stations E-835.0' and E-835.5' were collected from this interval. Contact with underlying bed (E-24) is gradational.		
	Sample E-29.		
	Ammodiscus sp.	<1P	
	Bathysiphon sp.	1P	
	Earlandinita sp.	<1P	
	Lituotuba sp.	<1P	
	Lindstroemella cf. L. patula	1	
	Mesolobus decipiens (articulated and disarticulated)	2P	
	Pseudorthoceras sp. (broken specimens)	3	
	Crinoid debris (columnals)	8	
	Pyritic bodies (small, black)	<1P	
	Quartz grains subangular to subrounded, fine to very fine sand size	<1P	
		Total	5.0

Note: The above sample (E-29) is not truly representative of this unit. This is the bed and location from which the samples for Station E-835.5' were collected. A short

Section E--Continued

Bed	Description	Thickness (feet)
E-25--(Continued)		
	distance away, at Station E-835.0', the fossil assemblage is much more diverse and abundant (See data in Appendix III for this Station and compare to Station 835.5').	
E-25 (upper 11.0')	Yellowish gray (5Y7/2) to greenish gray (5GY6/1) and light olive gray (5Y6/1) fresh, lighter shades of these colors weathered, blocky, "crumbly," carbonaceous, micaceous, silty and sandy, sparsely fossiliferous claystone with numerous light brown (5YR5/6) to dark yellowish orange (10YR6/6) ironstone nodules and/or concretions of various sizes and shapes. Contact with lower 5.0' of this bed (E-25) is gradational, difficult to place. Top covered.	

Sample E-30; Washed residue:

<u>Ammodiscus</u> sp.	2P
<u>Bathysiphon</u> sp.	3P
<u>Earlandinita</u> sp.	2P
<u>Lituotuba</u> sp.	1P
<u>Reophax</u> sp.	<1P
Pyritic objects (small, spherical, black)	2P
Quartz grains, subangular to subrounded, fine to very fine sand size	20P

Total 11.0

E-26	Covered, probably interbedded sandstones and claystones. Total	28.0
E-27	Pale yellowish orange (10YR8/6) to grayish orange (10YR7/4) and very pale orange (10YR8/2) fresh, moderate yellowish brown (10YR5/4) to light brown (5YR5/6) and dark yellowish orange (10YR6/6) weathered, fine to very fine sand size, fairly well sorted, fair to poorly cemented (friable), subrounded to subangular, ferruginous, cross bedded, medium thick bed of quartz sandstone. Some plant debris and molds of plants are present. Top and base covered.	

Sample E-31.

Total 1.0

Section E--Continued

Bed	Description	Thickness (feet)
E-28	Covered, probably sandstone as below (bed E-27), portion of Sigillaria branch found as float.	
	Total	2.5
E-29	Sandstone as below (bed E-27); thin to medium, irregular bedding. Top and base covered. Sample E-31A.	
	Total	2.5
E-30	Covered, probably sandstone as below (bed E-27).	
	Total	3.7
E-31	Sandstone as below (bed E-27), thin irregular bedding near base, medium to thick beds at top. Top and base covered. Sample E-31B.	
	Total	3.3
	TOTAL THICKNESS	128.3

Section F

Starts at an elevation of 758.4', ±15.0'N. of C. of W. line of SW$\frac{1}{4}$, NW$\frac{1}{4}$, NW$\frac{1}{4}$, NW$\frac{1}{4}$, Sec. 33, T. 7 N., R. 9 E., in stream bank (water level), proceeds NE to base of open glade, across glade (eastward) to the top of the glade and ends at an elevation of 809.25' near the C. of the N$\frac{1}{2}$, SE$\frac{1}{4}$, SE$\frac{1}{4}$, NW$\frac{1}{4}$, NW$\frac{1}{4}$, NW$\frac{1}{4}$, NW$\frac{1}{4}$, Sec. 33, T. 7 N., R. 9 E., Hughes County, Oklahoma. In terms of the three reference points the top is: 2386.0' N.7°0'E. of point 1, 1545.0' N.42°0'W. of point 2, and 1470.0' N.44°15'W. of point 3; the base is: 2153.0' N.0°30'E. of point 1, 1615.0' N.54°30'W. of point 2, and 1557.0' N.57°30'W. of point 3.

Majority of section measured along the southeast and east sides and the south center of a glade which is northwest of the W.P.A. dam and northeast of the permanent stream. The base is approximately 300.0' downstream from the mouth of the fifth large gully on the northeast side

Section F--Continued

side of this permanent stream. This fifth gully roughly parallels the stream. Start on the northeast bank of the permanent stream, below (1790.0' along stream course northwest of the center of) the W.P.A. dam; measure (beds F-1 and F-2) 3.8' vertically and 15.0' horizontally N.40°0'E. to an elevation of 762.2'; continue (bed F-3 lower part) 13.80' vertically and 125.0' horizontally along a sparsely wooded slope gradually swinging due east to an elevation of 776.0'; offset -1.75' vertically and 85.0' horizontally N.15°0'W. to an elevation of 774.25'; measure (beds F-4 through F-9, floor and lower part of glade slope) 3.75' vertically and 35.0' horizontally S.15°0'E. to an elevation of 778.0'; offset 33.0' horizontally S.83°0'E. to an elevation of 778.0'; measure beds F-10 through the lower 0.3' of F-18, up the lower middle part of the glade slope) 8.80' vertically and 52.0' horizontally S.51°0'E. to an elevation of 786.80'; offset 103.75' horizontally N.53°0'E. to an elevation of 786.80'; measure (middle 6.2' of bed F-18, upper middle part of glade slope) 6.2' vertically and 20.0' horizontally S.51°0'E. to an elevation of 793.0'; offset 30.0' horizontally N.4°0'W. to an elevation of 793.0'; measure (upper 1.3' of bed F-18 through the lower 3.2' of bed F-20, lower upper part of glade slopes) 9.5' vertically and 17.5' horizontally N.33°0'E. to an elevation of 802.5'; offset 20.0' horizontally N.30°0'W. to an elevation of 802.5'; measure (remainder of beds, uppermost part of glade slopes) 6.75' vertically and 22.5' horizontally N.36°0'E. to an elevation of 809.25'.

Bed	Description	Thickness (feet)
F-1	Light brown (5YR5/6) to dark yellowish orange (10YR6/6) fresh, moderate brown (5YR3/4 to 5YR4/4) and dark reddish brown (10R3/4) weathered, soft, discontinuous, non-fossiliferous nodules of iron oxide (goethite). Originally may have been siderite. Some have selenite crystals on exterior.	
	Sample F-1.	
	Total	0.2
F-2	Mottled medium gray (N-5) to medium dark gray (N-4) and light olive gray (5Y6/1) with light brown (5YR5/6) to dark yellowish orange (10YR6/6) fresh, slightly lighter shades of these colors weathered, moderately hard, finely carbonaceous, slightly pyritic, micaceous, blocky to slightly platy, fossiliferous claystone with "nodular" fracture. Abundant selenite crystals (small) on some bedding planes. Top covered.	
	Sample F-2; Washed residue:	
	<u>Ammodiscus</u> sp. 2P	
	<u>Bathysiphon</u> sp. 1P	

Section F--Continued

Bed	Description	Thickness (feet)
F-2--(Continued)		

Reophax sp.	<1P
Crurithyris planoconvexa (articulated, internal mold)	1
Productoid (fragment, dictyoclostid?)	1
Anthraconeilo taffiana (articulated, internal mold)	1
Nuculopsis (P.) wewokana (articulated, internal mold)	1
Hollinellid (articulated,. internal mold)	1
Scolecodonts	3
Hindeodellids (fragments)	3
?Idiognathodus sp.	1
?Streptognathodus	1
Unidentifiable conodonts (fragments	2
Fish debris	1
Faecal pellets	20P
Pyritic masses (coprolites?)	15
Gypsum (small crystals and aggregates)	30P

Total 3.6

F-3 Covered, probably claystone. 12.05

F-4 Light olive gray (5Y5/2 to 5Y6/1) to slightly greenish gray (5GY6/1) fresh, lighter shades of these colors weathered, moderately hard to soft, very slightly calcareous, micaceous, carbonaceous (finely divided), blocky to slightly platy claystone with ironstone nodules as described for bed F-1 below. Base covered.

Sample E-3A; Washed residue:

Ammodiscus sp.	2P
Bathysiphon sp.	2P
Earlandinita sp.	<1P
Endothyranella sp.	<1P
Lituotuba sp.	1P
Reophax sp.	1P
Tolypammina sp.	<1P
Lingula cf. L. carbonaria (articulated)	1
?Composita sp.	1
Crurithyris planoconvexa (articulated, various sizes)	2P
Mesolobus sp. (small, articulated)	1

Section F--*Continued*

Bed	Description		Thickness (feet)
F-4--(*Continued*)			
	Plagioglypta sp. (broken specimen)	<1P	
	Anthraconello taffiana (articulated, various sizes)	1P	
	Nuculopsis girtyi (articulated)	1	
	Nuculopsis (*P.*) *wewokana* (articulated, immature)	<1P	
	Polidevica bellistriata (articulated, various sizes)	10	
	Euphemites carbonarius (various sizes)	4	
	Glabrocingulum (*A.*) *grayvillensis* (various sizes)	2P	
	Ianthinopsis sp.	<1P	
	Meekospira peracuta (various sizes)	1P	
	Trepospira depressa (various sizes)	3P	
	?*Gastrioceras* sp.	1	
	Cavellina sp. (articulated)	2	
	Echinoid debris (spines)	1P	
	Holothurian debris (sclerites)	<1P	
	Ophiuroid and/or Asteroid debris (ossicles)	<1P	
	Idiognathodus sp.	1	
	Unidentifiable conodonts (fragments)	1	
	Faecal pellets	15P	
		Total	1.4
F-5	Nodular horizon dominated by two types of nodules. Type 1 is as described for bed F-1 below and is the dominant type. They lack the gypsum crystals on the exterior which are common on those of bed F-1. Type 2 is as follows: medium gray (N-5) to light olive gray (5Y6/1) to dusky yellow (5Y6/4) fresh, slightly lighter shades of these colors weathered, hard, non-fossiliferous, very argillaceous, ferrugineous nodules of carbonate mudstone. Some of these are septaria with thin veins of calcite radiating from the center and also forming more or less concentric rings. The entire horizon is discontinuous and undulatory.		
	Sample F-3B.		
		Total	0.1
F-6	Lithologically the same as bed F-4 below. The ironstone nodules are slightly larger (10-20 mm.) but		

Section F--Continued

Bed	Description	Thickness (feet)

F-6--(Continued)

the smaller ones are also still present. Samples from Station F-776.8' were collected from this bed.

Sample F-3C; Washed residue:

Ammodiscus sp.	2P
Bathysiphon sp.	2P
Earlandinita sp.	<1P
Endothyranella sp.	<1P
Lituotuba sp.	1P
Reophax sp.	1P
Tolypammina sp. (epizoan on shell fragments)	<1P
Lingula cf. L. carbonaria (articulated)	1
Lindstroemella cf. L. patula	1
Crurithyris planoconvexa (articulated & disarticulated, various sizes)	1P
Mesolobus decipiens (brachial valve)	1
Plagioglypta sp. (broken specimen)	<1P
Anthraconeilo taffiana (articulated, various sizes)	1P
Nuculopsis (P.) wewokana (articulated)	<1P
Polidevica bellistriata (articulated)	2
Euphemites carbonarius (various sizes)	4
Glabrocingulum (A.) grayvillensis (various sizes)	2P
Ianthinopsis sp. (small)	<1P
Meekospira peracuta (various sizes, broken)	<1P
Pseudozygopleurids	1
Trepospira depressa (various sizes)	2P
Pseudorthoceras sp. (broken specimen)	1
?Gastrioceras sp. (small)	<1P
Cavellina sp. (articulated)	2
Healdia sp. (articulated)	1
Crinoid debris (columnals)	3
Echinoid debris (spines, pedicellaria & plates)	2P
Holothurian debris (sclerites)	<1P
Ophiuroid and/or Asteroid debris (ossicles)	<1P
Hindeodellids (fragments)	<1P
Fish debris	1
Faecal pellets	9P

Total 1.0

Section F--*Continued*

Bed	*Description*		*Thickness* (feet)
F-7	Lithologically the same nodules as type 1 at bed F-5 below. Non-fossiliferous, discontinuous and undulatory.		
	Sample F-3D.		
	Total		0.1
F-8	Lithologically the same as bed F-4 below.		
	Sample F-3E; Washed residue:		
	Ammodiscus sp.	4P	
	Bathysiphon sp.	5P	
	Earlandinita sp.	2P	
	Endothyra sp.	1	
	Lituotuba sp.	<1P	
	Reophax sp.	<1P	
	Linguloid inarticulates	2	
	Chonetoid (articulated, small)	1	
	Crurithyris planoconvexa (articulated & disarticulated, various sizes)	5	
	Plagioglypta sp. (broken specimen)	<1P	
	Anthraconeilo taffiana (articulated)	2	
	Nuculopsis (*P.*) *anodontoides* (articulated)	1	
	Nuculopsis (*P.*) *wewokana* (articulated, various sizes)	3	
	Polidevica bellistriata (articulated, various sizes)	3	
	Euphemites carbonarius	2	
	Glabrocingulum (*A.*) *grayvillensis* (various sizes)	3P	
	Ianthinopsis sp. (various sizes)	<1P	
	Meekospira peracuta (various sizes)	9	
	?Pseudozygopleurids	<1P	
	Trepospira depressa (various sizes)	1P	
	Crinoid debris (columnals, plates & spines)	<1P	
	Echinoid debris (spines & plates)	3	
	Holothurian debris (sclerites)	<1P	
	Ophiuroid and/or Asteroid debris (ossicles)	3	
	Scolecodonts (fragments)	5	
	Gnathodus sp.	1	
	Hindeodellids (fragments)	3	
	Streptognathodus sp.	1	
	Faecal pellets	10P	
	Wood fragments	2	
	Total		1.0

Section F--Continued

Bed	Description	Thickness (feet)
F-9	Ironstone nodule horizon like those of type 1 in bed F-5. Non-fossiliferous, discontinuous and undulatory.	
	Sample F-3F.	
	Total	0.15
F-10	Claystone as below at bed F-4. There are larger ironstone nodules (60x40x10 mm.) as well as the smaller ones. Some are septaria.	

Samples F-3G and F-4A: Washed residues:

Ammobaculites sp.	1
Ammodiscus sp.	5P
Bathysiphon sp.	6P
Earlandinita sp.	3P
Endothyra sp.	3
Lituotuba sp.	1P
Reophax sp.	1P
Tolypammina sp. (encrusting on shell debris)	2
Lingula cf. L. carbonaria (small, articulated)	1
Lindstroemella cf. L. patula	1
Crurithyris planoconvexa (articulated and disarticulated, various sizes)	8
Mesolobus euampygus (articulated, various sizes, one specimen with Lindstroemella cf. L. patula on brachial valve)	3
Plagioglypta sp. (broken specimen)	1P
Anthraconeilo taffiana (articulated, various sizes)	2P
Nuculopsis (P.) anodontoides (articulated, various sizes)	1P
Nuculopsis (P.) wewokana (articulated, various sizes)	1P
Paleyoldia glabra (articulated)	1
Polidevica bellistriata (articulated and disarticulated, various sizes)	10
Euphemites carbonarius (small)	2
Girtyspira sp.	4
Glabrocingulum (A.) grayvillensis (various sizes)	5P
Ianthinopsis sp.	<1P
Meekospira peracuta (various sizes, broken)	7
Pseudozygopleurids	2P

Section F--Continued

Bed	Description		Thickness (feet)
F-10--(Continued)			
	Trepospira depressa (various sizes)	2P	
	?Gastrioceras sp.	1	
	Amphissites sp. (articulated)	2	
	Healdia sp. (articulated)	1	
	Crinoid debris (columnals)	1P	
	Echinoid debris (plates, spines, pedicellaria, etc.)	5	
	Holothurian debris (sclerites)	1P	
	Ophiuroid ahd/or Asteroid debris (ossicles)	6	
	?Scolecodonts (fragments)	<1P	
	Hindeodellid (fragment)	1	
	Fish debris	<1P	
	Faecal pellets	10P	
	Total		2.6
Note:	Sample of float collected (F-3) from interval represented by beds F-4 through the lower 1.2' of bed F-10. Lower part (floor) of glade.		
F-11	Ironstone nodule horizon like type 1 of bed F-5 but larger (60x40x10 mm.). Non-fossiliferous, discontinuous and undulatory.		
	Sample F-4B.		
	Total		0.1
F-12	Claystone as below at bed F-10.		
	Sample F-C; Washed residue:		
	Ammodiscus sp.	5P	
	Bathysiphon sp.	6P	
	Earlandinita sp.	3P	
	Endothyra sp.	3	
	Lituotuba sp.	1P	
	Reophax sp.	1P	
	Lingula cf. L. carbonaria (articulated, small)	1	
	Lindstroemella cf. L. patula	1	
	Crurithyris planoconvexa (articulated, various sizes)	4	
	Plagioglypta sp. (broken specimen)	1P	

Section F--Continued

Bed	Description		Thickness (feet)
F-12--(Continued)			
	Anthraconeilo taffiana (articulated, various sizes)	2P	
	Nuculopsis (*P.*) *anodontoides* (articulated, various sizes)	1P	
	Nuculopsis (P.) *wewokana* (articulated, various sizes)	1P	
	Paleyoldia glabra (articulated)	1	
	Polidevica bellistriata (articulated)	1	
	Euphemites carbonarius	2	
	Girtyspira sp.	3	
	Glabrocingulum (*A.*) *grayvillensis* (various sizes)	5P	
	Ianthinopsis sp.	<1P	
	Meekospira peracuta (various sizes, broken)	5	
	Pseudozygopleurids	2P	
	Trepospira depressa (various sizes)	2P	
	Amphissites sp. (articulated)	2	
	Crinoid debris (columnals)	1P	
	Echinoid debris (plates,. spines, pedicellaria, etc.)	5	
	Holothurian debris (sclerites)	1P	
	Ophiuroid and/or Asteroid debris (ossicles)	6	
	Scolecodonts (fragments)	<1P	
	Hindeodellid (fragment)	1	
	Fish debris	<1P	
	Faecal pellets	10P	
	Total		0.9
F-13	Ironstone nodule horizon like type 1 of bed F-5. Size as in bed F-11. Non-fossiliferous, discontinuous and undulatory.		
	Sample F-4D.		
	Total		0.1
F-14	Claystone as below at bed F-10. Samples of Stations F-781.7' and F-782.4' were collected from this bed.		
	Sample F-4E; Washed residue:		
	Ammodiscus sp.	5P	
	Bathysiphon sp.	6P	

Section F--*Continued*

Bed	Description	Thickness (feet)
F-14--(*Continued*)		

Earlandinita sp.	3P
Endothyra sp.	3
Lituotuba sp.	1P
Reophax sp.	1P
Lingula cf. *L. carbonaria* (articulated, small)	1
Lindstromella cf. *L. patula*	1
Crurithyris planoconvexa (articulated, various sizes)	4
Plagioglypta sp. (broken specimen)	1P
Anthraconeilo taffiana (articulated, various sizes)	2P
Nuculopsis (*P.*) *wewokana* (articulated)	1
Paleyoldia glabra (articulated)	1
Polidevica bellistriata (articulated, various sizes)	3
Euphemites carbonarius	2
Girtyspira sp.	3
Glabrocingulum (*A.*) *grayvillensis* (various sizes)	5P
Ianthinopsis sp.	<1P
Meekospira peracuta (various sizes, broken)	4
Pseudozygopleurids	2P
Trepospira depressa (various sizes)	2P
?*Gastrioceras* sp.	<1P
Amphissites sp. (articulated)	2
Crinoid debris (columnals)	1P
Echinoid debris (plates, spines, pedicellaria, etc.)	5
Holothurian debris (sclerites)	1P
Ophiuroid and/or Asteroid debris (ossicles)	6
Scolecodonts (fragments)	<1P
Hindeodellid (fragment)	1
Ozarkodina sp. (fragment)	1
Faecal pellets	8P
Quartz grains, subrounded to subangular, fine to very fine sand size.	1P

Total 3.4

Note: Sample of float collected (F-4) from interval represented by upper 1.4' of bed F-10 through the lower 2.5' of bed F-14.

F-15 Ironstone nodule horizon like type 1 of bed F-5. Size as in bed F-11. Non-fossiliferous, discontinuous and undulatory.

Section F--Continued

Bed	Description	Thickness (feet)
F-15--(Continued)		
	Sample F-5A.	
	Total	0.2
F-16	Lithologically the same as the claystone of bed F-10.	

Sample F-5A; Washed residue:

Ammobaculites sp.	<1P
Ammodiscus sp.	1P
Bathysiphon sp.	1P
Earlandinita sp.	<1P
Endothyranella sp.	2
Lituotuba sp.	1P
Reophax sp.	1P
Tolypammina sp. (epizoan)	<1P
?Sponge spicules	1
Linguloid brachiopods (articulated, small)	3
Crurithyris planoconvexa (articulated)	1
Plagioglypta sp. (broken specimen)	<1P
Anthraconeilo taffiana (articulated, immature)	1P
Nuculopsis (P.) wewokana (articulated, various sizes)	<1P
Polidevica bellistriata (articulated)	2
Euphemites carbonarius (small)	<1P
Glabrocingulum (A.) grayvillensis (various sizes)	3P
Ianthinopsis sp.	<1P
Meekospira peracuta (various sizes)	3
Pseudozygopleurids	4
Trepospira depressa (various sizes)	1P
?Gastrioceras sp. (small)	4
Amphissites sp. (articulated)	1
Crinoid debris (columnals)	2
Echinoid debris (spines)	4
Holothurian debris (sclerites)	<1P
Ophiuroid and/or Asteroid debris (ossicles)	1P
?Scolecodont (fragment)	1
Faecal pellets	12P

Total 1.1

Bed	Description	Thickness (feet)
F-17	Ironstone nodule horizon like type 1 of bed F-5. Size as in bed F-11. Non-fossiliferous, discontinuous and undulatory.	

Section F--Continued

Bed	Description		Thickness (feet)
F-17--(Continued)			
	Sample F-5B.		
	Total		0.1
F-18 (lower 2.8')	Lithologically the same as bed F-10 with some mottling of medium gray (N-5) to medium light gray (N-6). Nuculoid pelecypod collected in "life position" (Stanley, 1968).		
	Samples F-5 and F-5D; Washed residues:		
	Ammodiscus sp.	2P	
	Bathysiphon sp.	2P	
	Earlandinita sp.	2	
	Endothyranella sp.	1P	
	?Globovalvulina sp.	2	
	Lituotuba sp.	1P	
	Reophax sp.	<1P	
	Tolypammina sp. (epizoan)	<1P	
	Linguloid brachiopods (articulated)	1	
	Crurithyris planoconvexa (articulated, immature)	3	
	Plagioglypta sp. (broken specimen)	10	
	Anthraconeilo taffiana (articulated, various sizes)	9	
	Nuculopsis girtyi (articulated, various sizes)	3	
	Nuculopsis (P.) wewokana (articulated and disarticulated, various sizes)	6	
	Polidevica bellistriata (articulated)	1	
	Euphemites carbonarius	1	
	Glabrocingulum (A.) grayvillensis (various sizes)	42	
	Ianthinopsis sp. (various sizes)	3	
	Meekospira peracuta (various sizes)	4	
	Trepospira depressa (various sizes)	13	
	Pseudorthoceras sp. (broken)	1	
	?Gastrioceras sp. (small)	3	
	Bairdia sp. (articulated)	2	
	Cavellina sp. (articulated)	1	
	Crinoid debris (columnals, plates, etc.)	<1P	
	Echinoid debris (spines, plates, pedicellaria, etc.)	2P	
	Holothurian debris (sclerites)	<1P	
	?Scolecodonts (fragments)	<<1P	

Section F--Continued

Bed	Description		Thickness (feet)
F-18--(Continued)			
	Unidentifiable conodont (fragment)	1	
	Faecal pellets	12P	
	Total		2.8

Note: Sample of float collected (F-5) from interval represented by upper 0.9' of bed F-15 through the lower 2.8' of bed F-18.

F-18 (upper 5.0')	Claystone as below (lower 2.8' of bed F-18). Float sample F-6S was collected from this interval. Samples from Stations F-789.9' and F-791.2' were collected from this bed.		
	Sample F-6; Washed residue:		
	Ammodiscus sp.	2P	
	Bathysiphon sp.	2P	
	Earlandinita sp.	2	
	Endothyranella sp.	1P	
	?Globovalvulina sp.	2	
	Lituotuba sp.	1P	
	Reophax sp.	<1P	
	Tolypammina sp. (epizoan)	<1P	
	Ramose Bryozoans (corroded)	5	
	Linguloid brachiopods (articulated)	1	
	Chonetoid (immature)	1	
	Crurithyris planoconvexa (articulated, immature)	3	
	Plagioglypta sp.(broken specimens)	10	
	Anthraconeilo taffiana (articulated, various sizes)	7	
	Nuculopsis girtyi (articulated)	2	
	Nuculopsis (P.) wewokana (articulated & disarticulated, various sizes)	8	
	Polidevica bellistriata (immature, articulated)	1	
	Euphemites carbonarius	10	
	Glabrocingulum (A.) grayvillensis (various sizes)	26	
	Ianthinopsis sp. (various sizes)	3	
	Meekospira peracuta (various sizes)	4	
	Trepospira depressa (various sizes)	14	
	?Gastrioceras sp. (small)	3	
	Bairdia sp. (articulated)	1	
	Cavellina sp. (articulated)	3	

Section F--Continued

Bed	Description		Thickness (feet)
F-18--(Continued)			
	Crinoid debris (columnals, plates, etc.)	<1P	
	Echinoid debris (spines, plates, pedicellaria, etc.)	2P	
	Holothurian debris (sclerites)	<1P	
	Ophiuroid and/or Asteroid debris (ossicles)	2P	
	Ozarkodina sp. (fragment)	1	
	Faecal pellets	10P	
	Total		5.0
F-19	Claystone as below (lower 2.8' of bed F-18), slightly more calcareous and fewer ironstone nodules. Float sample F-7S was collected from this interval. The contact with the underlying bed (upper 5.0' of F-18) is gradational.		
	Sample F-7; Washed residue:		
	Ammodiscus sp.	3P	
	Bathysiphon sp.	2P	
	Earlandinita sp.	4	
	Endothyranella sp.	2	
	?Globovalvulina sp.	3	
	Lituotuba sp.	1P	
	Reophax sp.	<1P	
	Tolypammina sp. (epizoan)	<1P	
	Lingula cf. L. carbonaria (articulated)	2	
	Chonetoids (immature)	2	
	Crurithyris planoconvexa (articulated, immature)	1	
	Plagioglypta sp. (broken specimen)	10	
	Anthraconeilo taffiana (articulated, various sizes)	8	
	Astartella cf. A. concentrica (right valve)	1	
	Nuculopsis girtyi (articulated)	1	
	Nuculopsis (P.) anodontoides (articulated)	2	
	Polidevica bellistriata (articulated)	1	
	Euphemites carbonarius	10	
	Glabrocingulum (A.) grayvillensis (various sizes)	3P	
	Ianthinopsis sp. (various sizes)	3	
	Meekospira peracuta (various sizes)	4	
	Pseudozygopleurids	1	
	Trepospira depressa (various sizes)	1P	
	?Gastrioceras sp. (small)	1	

Section F--Continued

Bed	Description		Thickness (feet)
F-19--(Continued)			
	Amphissites sp. (articulated)	1	
	Moorites sp. (articulated)	1	
	Crinoid debris (columnals, plates, etc.)	1P	
	Echinoid debris (spines, plates, pedicellaria, etc.)	1P	
	Holothurian debris (sclerites)	1P	
	Ophiuroid and/or Asteroid debris (ossicles)	2P	
	Faecal pellets	10P	
	Total		5.0
F-20	Claystone as below (lower 2.8' of bed F-18), more calcareous, fewer ironstone nodules than bed F-19 and more platy and "crumbly" than blocky. Float sample F-8S collected from this interval. Contact with underlying bed (F-19) is gradational. Top covered.		
	Sample F-8; Washed residue:		
	Ammodiscus sp.	<1P	
	Bathysiphon sp.	2P	
	Earlandinita sp.	3P	
	Lituotuba sp.	<1P	
	Reophax sp.	<1P	
	Lophophyllum sp.	1	
	Ramose bryozoans (fragments of colonies)	2	
	Lingula cf. L. carbonaria (articulated)	1	
	Inarticulate brachiopod fragments (unidentifiable)	1	
	Plagioglypta sp. (broken specimen)	6	
	Anthraconeilo taffiana (articulated, various sizes)	6	
	Nuculopsis (P.) wewokana (articulated)	2	
	Euphemites carbonarius (small)	5	
	Glabrocingulum (A.) grayvillensis (various sizes)	10	
	Ianthinopsis sp.	3	
	Trepospira depressa (various sizes)	6	
	?Gastrioceras sp. (small)	7	
	Cavellina sp. (articulated)	1	
	Crinoid debris (plates & columnals)	19	
	Echinoid debris (plate)	1	
	Unidentifiable conodonts (fragments)	2	
	Fish debris	1	
	Faecal pellets	5P	
	Total		6.0

Section F--Continued

Bed	Description		Thickness (feet)
F-20--(Continued)			
Note:	Most of the larger invertebrates are preserved as internal molds or are badly corroded and abraded.		
F-21	Covered, probably claystone.	Total	3.45
F-22	Yellowish brown, "crumbly" soil. No sample collected.	Total	0.5+
		TOTAL THICKNESS	50.85+

Section G

Starts at an elevation of 764.8', ±10.0'S. of C. of E. line of NE$\frac{1}{4}$, SE$\frac{1}{4}$, NE$\frac{1}{4}$, NE$\frac{1}{4}$, NE$\frac{1}{4}$, NE$\frac{1}{4}$, Sec. 32. T. 7 N., R. 9 E., at the mouth of a gully, proceeds up the gully to an open glade, across and over the top of the glade to a sandstone exposure and ends at an elevation of 874.8' near the C. of SE$\frac{1}{4}$, SE$\frac{1}{4}$, SW$\frac{1}{4}$, SE$\frac{1}{4}$, SW$\frac{1}{4}$, SW$\frac{1}{4}$, SW$\frac{1}{4}$, Sec. 28, T. 7 N., R. 9 E., Hughes County, Oklahoma. In terms of the three reference points the top is: 2704.0' N.9°45'E. of point 1, 1677.0' N.31°0'W. of point 2 and 1590.0' N.32°30'W. of point 3; the base is: 2418.0' N.0°20'W. of point 1, 1782.0' N.55°0'W. of point 2 and 1715.0' N.58°0'W. of point 3.

Measured in a gully which trends northeast-southwest (southeast side of lower gully and northwest side of upper gully) and up the center of a glade, both are due north of the area of Section F. This gully does not intersect the permanent stream but opens out (southwest end) into a grazed, gently westward sloping area on the east side of the stream. The glade is situated at the northeast end of the gully. The course of the permanent stream has changed and flows in a north-northeast direction. Start at the mouth of the gully, which is 250.0' due north of the base of Section F and 65.0' due east of the permanent stream; measure (beds G-1 through the lower 6.6' of G-12) 35.0' vertically and 205.0' horizontally N.64°30'E. up the gully to the floor of the glade at an elevation of 799.8'; continue (middle 7.5' of bed G-12, lower part of glade slopes) 7.5' vertically and 50.0' horizontally in the same direction to an elevation of 807.3'; offset 10.0' S.48°0'E. to an elevation of 807.3';

Section G--Continued

measure (upper 5.3' of bed G-12 through bed G-20, upper part of glade slopes) 21.5' vertically and 49.0' horizontally due east to an elevation of 834.8'; continue 51.7' N.35°0'E. (lower? part of bed G-21); then 29.1' N.80°0'E. (middle? part of bed G-21); then 71.1' N.55°0'E. (upper? part of bed G-21); then 96.9' N.35°0'E. to a shallow gully which trends N.74°0'W. and exposes the sandstone (beds G-22 through G-25) below an elevation of 874.8'.

Bed	Description	Thickness (feet)
G-1	Covered, probably shale/claystone. Total	3.5

G-2 Light olive gray (5Y6/1) mottled with medium light gray (N-6) to medium gray (N-5) fresh, dusky yellow (5Y6/4) to medium light gray (N-6) weathered, very slightly calcareous, micaceous, blocky, carbonaceous, fossiliferous claystone with light brown (5YR5/6) to dark yellowish orange (10YR6/6) weathered, medium light gray (N-6) to medium gray (N-5) fresh, calcareous ironstone nodules. Size of nodules is similar to those of bed F-11 at Section F. Some small ±2-3 mm. in diameter burrow fillings? of iron oxide, oriented parallel to bedding. Top and base covered.

Samples G-1A and G-2A; Washed residues:

Ammobaculites sp.	1
Ammodiscus sp.	2P
Bathysiphon sp.	1P
Earlandinita sp.	2P
Endothyranella sp.	2
Reophax sp.	1P
Tolypammina sp. (epizoan)	2
Prismopora sp. (fragment of colony)	1
Ramose bryozoans (fragments of colony)	3
Lingula cf. L. carbonaria (articulated)	2
Lindstroemella sp. (fragment)	1
Chonetoid (immature)	1
Crurithyris planoconvexa (articulated and disarticulated, various sizes)	13
Mesolobus decipiens (articulated and disarticulated, various sizes)	4
Plagioglypta sp. (broken specimen)	9
Allorisma sp. (small, articulated)	1
Anthraconeilo taffiana (articulated, various sizes)	23

Section G--Continued

Bed	Description		Thickness (feet)
G-2--(Continued)			
	Nuculopsis (*P.*) *anodontoides* (articulated, small	1	
	Nuculopsis (*P.*) *wewokana* (disarticulated, small)	2	
	Polidevica bellistriata (articulated, various sizes)	11	
	Bellerophontids	1	
	Euphemites carbonarius (various sizes)	7	
	Girtyspira sp.	1	
	Glabrocingulum (*A.*) *grayvillensis* (various sizes)	20	
	Ianthinopsis sp. (various sizes)	7	
	Meekospira peracuta (various sizes, broken)	13	
	Pseudozygopleurids	1	
	Trepospira depressa (various sizes)	25	
	Pseudorthoceras sp. (broken)	1	
	?*Gastrioceras* sp.	13	
	Trilobite fragments (?*Ditomoypge* sp.)	1	
	Cavellina sp. (articulated)	2	
	Healdia sp. (articulated)	6	
	Crinoid debris (columnals, plates, etc.)	28	
	Echinoid debris (plates, spines, pedicellaria)	<1P	
	Ophiuroid and/or Asteroid debris (ossicles)	14	
	Faecal pellets	8P	
	Wood fragments	2	
	Total		3.8
Note:	Sample of float was collected (G-1) representing bed G-1 through the lower 1.3' of bed G-2.		
G-3	Covered, probably claystone. Samples of Station G-774.7' were dug from this interval (near the top of this interval and the exposed base of bed G-4).		
	Total		2.7
Note:	Sample of float was collected (G-2) representing the upper 2.3' of bed G-2 and bed G-3.		
G-4	Claystone as below at bed G-2 but lacks the ironstone nodules. Base is covered.		

Section G--Continued

Bed	Description	Thickness (feet)

G-4--(Continued)

Sample G-3A; Washed residue:

Ammodiscus sp.	2P
Bathysiphon sp.	1P
Earlandinita sp.	3
Endothyranella sp.	<1P
Lituotuba sp.	≪1P
Reophax sp.	<1P
Ramose bryozoans (abraded, corroded)	1
Cruritnyris planoconvexa (articulated, various sizes)	3
Plagioglypta sp. (broken specimen)	5
Anthraconeilo taffiana (articulated)	1
Nuculopsis (P.) wewokana (articulated, immature)	2
Polidevica bellistriata (articulated)	1
Glabrocingulum (A.) grayvillensis	2
Ianthinopsis sp.	3
Meekospira peracuta (various sizes)	4
Trepospira depressa (various sizes)	3
Crinoid debris (columnal)	1
Echinoid debris (spines)	2
Holothurian debris (sclerites)	1
Ophiuroid and/or Asteroid debris (ossicles)	3
Faecal pellets	15P
Gypsum (crystals and aggregates)	35P

Total 0.4

G-5 Light brown (5YR5/6) to dark yellowish orange (10YR6/6) fresh, slightly lighter shades of these two colors weathered, moderately hard, slightly calcareous, discontinuous, non-fossiliferous, undulatory horizon of ironstone nodules and concretions.

Sample G-3B.

Total 0.1

G-6 Claystone as below at bed G-2 with associated ironstone nodules. Top covered.

Sample G-3C; Washed Residue:

Ammodiscus sp.	<1P
Bathysiphon sp.	<1P

Section G--Continued

Bed	Description	Thickness (feet)
G-6--(Continued)		

Earlandinita sp.	<1P
Fusulina sp. (abraded & corroded)	1
Reophax sp.	<1P
Ramose bryozoans (fragments of colonies)	2
Lingula cf. *L. carbonaria* (articulated)	1
Plagioglypta sp. (broken specimen)	7
Anthraconeilo taffiana (articulated, various sizes)	6
Nuculopsis (*P.*) *wewokana* (articulated, immature?)	4
Polidevica bellistriata	1
Glabrocingulum (*A.*) *grayvillensis* (various sizes)	18
Meekospira peracuta (small)	4
Pseudozygopleurids	2
Trepospira depressa (various sizes)	10
?*Gastrioceras* sp.	1
Crinoid debris (columnals)	13
Echinoid debris (spines & plates)	9
Ophiuroid and/or Asteroid debris (ossicles)	1
Faecal pellets	4P
Gypsum (crystals & aggregates)	30P

Total 1.85

Note: Sample of float was collected (G-3) representing beds G-4, G-5, G-6 and the lower 2.65' of G-7.

G-7 Covered, probably claystone.

Total 7.65

Note: Sample of float was collected (G-4) from the upper 5.0' of bed G-7.

G-8 Claystone as below at bed G-2 with some ironstone nodules and slightly more calcareous. Top and base covered.

Sample G-5A; Washed Residue:

Ammodiscus sp.	1P
Bathysiphon sp.	<1P
Endothyranella sp.	2

Section G--Continued

Bed	Description		Thickness (feet)
G-8--(Continued)			
	Lituotuba sp.	1	
	Plagioglypta sp. (broken specimen)	4	
	Anthraconeilo taffiana (various sizes)	6	
	Nuculopsis (P.) wewokana (immature?)	3	
	Euphemites carbonarius	2	
	Glabrocingulum (A.) grayvillensis (various sizes)	13	
	Ianthinopsis sp.	2	
	Trepospira depressa	1	
	Cavellina sp. (articulated, various sizes)	4	
	Crinoid debris (columnals)	6	
	Echinoid debris (spines)	1	
	Holothurian debris (sclerites)	<1P	
	Ophiuroid and/or Asteroid debris (ossicles)	7	
	Faecal pellets	5P	
		Total	0.5
G-9	Covered, probably claystone.		
		Total	2.5
G-10	Claystone as below at bed G-2 with some ironstone nodules and slightly more calcareous. Top and base covered.		
	Sample G-5B; Washed residue:		
	Ammodiscus sp.	2P	
	Bathysiphon sp.	1P	
	Lituotuba sp.	<1P	
	Reophax sp.	1P	
	Lingula cf. L. carbonaria (articulated)	1	
	Lindstroemella cf. L. patula	2	
	Plagioglypta sp. (broken specimen)	2	
	Anthraconeilo taffiana (articulated, immature)	3	
	Polidevica bellistriata (articulated, small)	1	
	Euphemites carbonarius (small)	2	
	Glabrocingulum (A.) grayvillensis (small)	4	
	Pseudozygopleurid	1	
	?Gastrioceras sp.	1	
	Trilobite genal spine (probably Ameura sp.)	1	
	Cavellina sp. (articulated, various sizes)	5	
	Crinoid debris (columnals)	5	

Section G--Continued

Bed	Description		Thickness (feet)
G-10--(Continued)			
	Echinoid debris (spines)	2	
	Fish debris (tooth?)	1	
	Faecal pellets	8P	
	Total		0.75
G-11	Covered, probably claystone.		
	Total		4.65

Note: Sample of float collected (G-5) from interval represented by beds G-8, G-9, G-10 and the lower 1.25' of bed G-11.

G-12 (lower 1.6') Claystone as below at bed G-2 with a few ironstone nodules and slightly more calcareous. Base covered.

Sample G-6A; Washed residue:

Ammodiscus sp.	<1P
Bathysiphon sp.	≪1P
Earlandinita sp.	<1P
Endothyranella sp.	4P
Fusulina sp.	1
Globovalvulina sp.	1
Lituotuba sp.	3
Tolypammina sp. (epizoans)	20
Lophophyllum sp. (fragments)	2
Fenestrate bryozoans (small fragment of a colony)	1
Fistuliporids (fragment)	1
Ramose bryozoans (fragments of colonies)	13
Cleiothyridina orbicularis (articulated, immature)	4
Chonetinella sp. (articulated, various sizes)	11
Crurithyris planoconvexa (articulated & disarticulated)	3
Mesolobus euampygus (articulated & disarticulated, various sizes)	7
Productoid spines	2
Plagioglypta sp. (broken specimen)	3
Nuculopsis (P.) wewokana (articulated)	1
Polidevica bellistriata (left valve)	1
Euphemites carbonarius	2

Section G--Continued

Bed	Description		Thickness (feet)
G-12--(Continued)			
	Glabrocingulum (A.) grayvillensis (various sizes)	12	
	Ianthinopsis sp.	2	
	Meekospira peracuta (small)	4	
	Pseudozygopleurids	11	
	Pseudorthoceras sp. (broken specimen)	2	
	?Gastrioceras sp. (small)	1	
	Ditomopyge cf. D. parvulus (complete specimen)	1	
	Trilobite debris	7	
	Amphissites sp. (articulated & disarticulated, various sizes)	10	
	Bairdia sp. (articulated, various sizes)	7	
	Cavellina sp. (articulated, various sizes)	5	
	Healdia sp. (articulated, various sizes)	3	
	?Hollinella sp. (articulated, various sizes)	4	
	Moorites sp. (articulated, various sizes) (Ostracodes total 6P)	3	
	Crinoid debris (columnals, plates, brachial, etc.)	22	
	Echinoid debris (plates and spines)	10	
	Holothurian debris (sclerites)	4	
	Total		1.6

Note: Sample of float collected (G-6) which represents the upper 3.4' of bed G-11 and the lower 1.6' of bed G-12.

G-12 (next higher 5.0') Light olive gray (5Y6/1) fresh, lighter shades of this color weathered, blocky to platy, micaceous, calcareous, slightly carbonaceous, fossiliferous, moderately hard claystone with very few ironstone nodules as described for bed G-5 below. There are the same type of calcareous nodules present in this bed as are described for the upper 2.0' of bed E-22. Sample of float collected (G-7) from this 5.0' interval.

Sample G-7A; Washed residue:

Ammodiscus sp.	<<1P
Bathysiphon sp.	<1P
Earlandinita sp.	<1P
Endothyranella sp.	4P
Fusulina sp.	1
Globovalvulina sp.	1
Lituotuba sp.	3

Section G--*Continued*

Bed	Description	Thickness (feet)

G-12--(*Continued*)

Tolypammina sp. (epizoans)	21
Lophophyllum sp. (fragments)	3
Fistuliporids (fragment)	1
Ramose bryozoans (fragments of colonies)	14
Inarticulate brachiopod fragments	5
Chonetinella sp. (articulated, various sizes)	10
Cleiothyridina orbicularis (articulated, immature)	5
Crurithyris planoconvexa (articulated & disarticulated)	3
Hustedia cf. *H. mormoni* (articulated)	1
Mesolobus euampygus (articulated & disarticulated, various sizes)	6
Plagioglypta sp. (broken specimen)	2
Anthraconeilo taffiana (articulated, various sizes)	7
Astartella cf. *A. concentrica* (left valves)	4
Nuculopsis (*P.*) *wewokana* (articulated)	1
Paleyoldia glabra (articulated)	1
Polidevica bellistriata (articulated)	2
Bellerophon (*B.*) *crassus*	2
Euphemites carbonarius (various sizes)	4
Glabrocingulum (*A.*) *grayvillensis* (various sizes)	22
Ianthinopsis sp.	3
Meekospira peracuta (various sizes)	5
Pseudozygopleurids	11
Trepospira depressa (various sizes)	4
Pseudorthoceras sp. (broken specimen)	10
?*Gastrioceras* sp. (small)	5
Trilobite debris	7
Amphissites sp. (articulated & disarticulated, various sizes)	9
Bairdia sp. (articulated, various sizes)	7
Cavellina sp. (articulated, various sizes)	5
Healdia sp. (articulated, various sizes)	3
?*Hollinella* sp. (articulated, various sizes)	4
Moorites sp. (articulated, various sizes) (Ostracodes total 5P)	3
Crinoid debris (columnals & brachial brachials)	41
Echinoid debris (plates, spines & jaw parts)	11
Holothurian debris (sclerites)	4
Ophiuroid and/or Asteroid debris (ossicles)	2
Gnathodus sp.	1

Section G--Continued

Bed	Description		Thickness (feet)
G-12--(Continued)			
	Hindeodellid (fragment)	1	
	Faecal pellets	1P	
	Total		5.0

G-12 (next higher 5.0')   Light olive gray (5Y6/1) with faint bluish cast (a color somewhere between light bluish gray (5B7/1) and medium bluish gray (5B5/1)) fresh, lighter shades of these colors weathered, blocky, micaceous, calcareous, very slightly carbonaceous, fossiliferous, moderately hard claystone with no ironstone nodules. Calcareous nodules as belowat bed G-12 (interval immediately below this one). Sample of float collected (G-8) from this 5.0' interval.

Sample G-8A; Washed residue:

Ammodiscus sp.	≪1P
Bathysiphon sp.	<1P
Earlandinita sp.	<1P
Endothyranella sp.	4P
Globovalvulina sp.	1
Lituotuba sp.	3
Tolypammina sp. (epizoans)	21
Lophophyllum sp. (fragments)	3
Fenestrate bryozoans (fragment of colony)	1
Fistuliporids (on crinoid columnal)	2
Ramose bryozoans (fragments of colony)	14
Chonetinella sp. (articulated, various sizes)	11
Cleiothyridina orbicularis (articulated, various sizes)	5
Crurithyris planoconvexa (articulated & disarticulated, various sizes)	16
Hustedia cf. *H. mormoni* (articulated)	1
Mesolobus euampygus (articulated & disarticulated, various sizes)	8
Productoid spines	1
Plagioglypta sp. (broken specimen)	3
Astartella cf. *A. concentrica* (disarticulated & fragments)	8
Nuculopsis (*P.*) *anodontoides* (articulated, immature)	3
Nuculopsis (*P.*) *wewokana* (articulated & disarticulated, various sizes)	11
Polidevica bellistriata (articulated & disarticulated, various sizes)	3
Schizodus sp. (disarticulated, various sizes)	4

Section G--Continued

Bed	Description		Thickness (feet)
G-12--(Continued)			
	Bellerophon (B.) crassus	2	
	Euphemites carbonarius (various sizes)	4	
	Glabrocingulum (A.) grayvillensis (various sizes)	22	
	Ianthinopsis sp.	3	
	Meekospira peracuta (broken, various sizes)	6	
	Pseudozygopleurids	11	
	Trepospira depressa (various sizes)	4	
	Straparolus (A.) catilloides (various sizes)	3	
	Pseudorthoceras sp. (broken specimen)	3	
	?Cycloceras sp. (broken specimen)	2	
	?Gastrioceras sp. (small)	5	
	Trilobite debris	7	
	Amphissites sp. (articulated & disarticulated, various sizes)	9	
	Bairdia sp. (articulated, various sizes)	7	
	Cavellina sp. (articulated, various sizes)	5	
	Healdia sp. (articulated, various sizes)	3	
	?Hollinella sp. (articulated, various sizes)	4	
	Moorites sp. (articulated, various sizes)	3	
	(Ostracodes total 5P)		
	Crinoid debris (columnals & brachials)	37	
	Echinoid debris (plates, spines and jaw parts)	14	
	Holothurian debris (sclerites)	4	
	Ophiuroid and/or Asteroid debris (ossicles)	2	
	Gnathodus sp.	1	
	Hindeodellid (fragment)	1	
	Faecal pellets	1P	
		Total	5.0
G-12 (next higher 5.0')	Claystone as below at bed G-12 (Sample G-8A). Samples of float collected from this interval (G-9A and G-9B).		
	Samples G-9A; and G-9B; Washed residues:		
	Ammobaculites sp.	5	
	Ammodiscus sp.	4	
	Earlandinita sp.	<1P	
	Endothyranella sp.	5	
	Fusulina sp.	14	
	Globovalvulina sp.	1	
	Lituotuba sp.	11	
	Tolypammina sp. (epizoans)	20	

Section G--Continued

Bed	Description	Thickness (feet)
G-12--(Continued)		
	Fistuliporids (epizoans)	3
	Ramose bryozoans (fragments of colonies)	20
	Chonetinella cf. C. flemingi (articulated, various sizes)	15
	Cleiothyridina orbicularis (articulated, disarticulated, various sizes)	40
	Crurithyris planoconvexa (articulated & disarticulated, various sizes)	23
	Derbyia sp. (fragments)	1
	Hustedia cf. H. mormoni (articulated & fragments)	8
	Marginiferids (fragments)	2
	Mesolobus decipiens (articulated, various sizes)	6
	Mesolobus euampygus (articulated & disarticulated, various sizes)	54
	Other Productoid debris (spines & shell fragments)	6
	Plagioglypta sp. (broken specimen)	8
	Anthraconeilo taffiana (articulated)	1
	Nuculopsis (P.) wewokana (articulated)	2
	Polidevica bellistriata (articulated)	1
	Euphemites carbonarius (small)	6
	Glabrocingulum (A.) grayvillensis (small)	4
	Ianthinopsis sp. (various sizes)	9
	Meekospira peracuta (various sizes)	9
	Pseudozygopleurids	18
	Straparolus (A.) catilloides (various sizes)	6
	Trepospira depressa (various sizes)	12
	Worthenia cf. W. tabulata	1
	Pseudorthoceras sp. (broken specimen)	3
	?Gastrioceras sp.	1
	Trilobite debris (genal spines, thoracic segments, etc.)	15
	Amphissites sp. (articulated, various sizes)	10
	Bairdia sp. (articulated, various sizes)	8
	Cavellina sp. (articulated, various sizes)	2
	Hollinella sp. (articulated, various sizes)	2
	Moorites sp. (articulated, various sizes)	2
	Crinoid debris (plates, columnals, brachials, etc.)	101
	Echinoid debris (spines, plates, jaw parts., etc.)	7
	Holothurian debris (sclerites)	10

Section G--*Continued*

Bed	Description		Thickness (feet)
G-12--(*Continued*)			
	Ophiuroid and/or Asteroid debris (ossicles)	6	
	Conodont (fragment)	1	
	Faecal pellets	<1P	
	Total		5.0
G-12 (upper 2.8')	Claystone as below at bed G-12 (Sample G-8A).		
	Sample G-10A; Washed residue:		
	Ammobaculites sp.	5	
	Ammodiscus sp.	4	
	Earlandinita sp.	<1P	
	Endothyranella sp.	5	
	Fusulina sp.	4	
	Globovalvulina sp.	1	
	Lituotuba sp.	11	
	Tolypammina sp. (epizoans)	20	
	Fistuliporids (epizoans)	1	
	Prismopora sp. (fragment of colony)	1	
	Ramose bryozoans (fragments of colonies)	15	
	Cleiothyridina orbicularis (articulated, various sizes)	12	
	Crurithyris planoconvexa (articulated, various sizes)	10	
	Hustedia cf. *H. mormoni* (articulated)	1	
	Marginiferid fragments	6	
	Mesolobus decipiens (articulated, various sizes)	7	
	Mesolobus euampygus (articulated, various sizes)	22	
	Other Productoid fragments	4	
	Plagioglypta sp. (broken specimen)	8	
	Anthraconeilo taffiana (articulated, immature)	2	
	Nuculopsis (P.) wewokana (articulated, immature?)	3	
	Polidevica bellistriata (articulated)	1	
	Euphemites carbonarius (small)	3	
	Glabrocingulum (A.) grayvillensis (small)	2	
	Ianthinopsis sp.	3	
	Meekospira peracuta	4	
	Pseudozygopleurids	12	
	Trepospira depressa (small)	6	
	?*Gastrioceras* sp.	1	
	Trilobite debris	4	
	Amphissites sp. (articulated, various sizes)	11	

Section G--Continued

Bed	Description		Thickness (feet)
G-12--(Continued)			
	Bairdia sp. (articulated, various sizes)	7	
	Cavellina sp. (articulated, various sizes)	3	
	Hollinella sp. (articulated, various sizes)	3	
	Moorites sp. (articulated, various sizes)	2	
	Crinoid debris (columnals, brachials & radials)	43	
	Echinoid debris (internal plates, spines, etc.)	5	
	Holothurian debris (sclerites)	12	
	Ophiuroid and/or Asteroid debris (ossicles)	1	
	Idiognathodus sp.	1	
	Faecal pellets	≪1P	
		Total	2.8
G-13	Light brown (5YR5/6) to dark yellowish orange (10YR6/6) fresh, moderate brown (5YR4/4) to light brown (5YR5/6) weathered, moderately hard, slightly calcareous, non-fossiliferous, discontinuous, undulatory horizon of ironstone nodules and concretions.		
	Sample G-10B.		
		Total	0.1
G-14	Claystone as below at bed G-12 (sample G-8A) but contains some ironstone nodules as described for bed G-13. This is the bed from which samples of Station G-815.1' and G-816.0' were collected.		
	Samples G-10C and G-11A; Washed residues:		
	Ammobaculites sp.	6	
	Ammodiscus sp.	3P	
	Bathysiphon sp.	2	
	Earlandinita sp.	8	
	Endothyranella sp.	6	
	Lituotuba sp.	4	
	Reophax sp.	2	
	Tolypammina sp. (epizoans)	30	
	Fistuliporids (epizoans)	1	
	Prismopora sp. (fragments of a colony)	5	
	Ramose bryozoans (fragments of a colony)	9	
	Cancrinella sp. (disarticulated fragments)	2	
	Cleiothyridina orbicularis (articulated & disarticulated, various sizes)	23	

Section G--Continued

Bed	Description		Thickness (feet)
G-14--(Continued)			
	Crurithyris planoconvexa (articulated, various sizes)	15	
	Mesologus decipiens (articulated, various sizes)	28	
	Mesolobus euampygus (articulated, various sizes)	42	
	Productoid spines	10	
	Plagioglypta sp. (broken specimen)	2	
	Nuculopsis girtyi (articulated)	1	
	Nuculopsis (P.) anodontoides (articulated, immature)	2	
	Nuculopsis (P.) wewokana (articulated, immature)	1	
	Polidevica bellistriata (articulated, immature)	1	
	Bellerophontid (fragment)	1	
	Euphemites carbonarius (immature)	4	
	Glabrocingulum (A.) grayvillensis (various sizes)	3	
	Ianthinopsis sp. (various sizes)	5	
	Meekospira peracuta (small)	4	
	Pseudozygopleurids	28	
	Trepospira depressa (broken)	3	
	Pseudorthoceras sp. (broken specimen)	1	
	Gastrioceras sp.	3	
	Trilobite debris	3	
	Amphissites sp. (articulated, various sizes)	14	
	Bairdia sp. (articulated, various sizes)	20	
	Healdia sp. (articulated, various sizes)	10	
	Hollinella sp. (articulated, various sizes)	2	
	Crinoid debris (columnals, brachials and radials)	106	
	Echinoid debris (internal & external plates)	27	
	Holothurian debris (sclerites)	$<1P$	
	Ophiuroid and/or Asteroid debris (ossicles)	10	
	?Scolecodonts (fragments)	4	
	Ozarkodina sp.	1	
	Faecal pellets	$\ll 1P$	
	Total		5.5

Note: Float sample G-10S collected from the interval represented by beds G-12 (upper 2.8'), G-13 and the lower 2.1' of G-14.

Section G--Continued

Bed	Description		Thickness
G-15	Ironstone nodule horizon as below at bed G-13.		
	Sample G-11B.		
	Total		0.1
G-16	Claystone as below at bed G-12 (sample G-8A) with ironstone nodules as described for bed G-13. Some mottling of grayish orange (10YR7/4).		
	Samples G-11C and G-12A; Washed residues:		
	Ammodiscus sp.	3P	
	Bathysiphon sp.	2P	
	Earlandinita sp.	1P	
	Lituotuba sp.	1	
	Reophax sp.	6	
	Crurithyris planoconvexa (pedicle valve)	1	
	Mesolobus euampygus (articulated & disarticulated, various sizes)	18	
	Productoid spines	16	
	Plagioglypta sp.	3	
	Anthraconeilo taffiana (articulated, various sizes)	3	
	Astartella sp. (fragment)	1	
	Euphemites carbonarius (small)	5	
	Girtyspira sp.	1	
	Meekospira peracuta (small)	2	
	Pseudozygopleurids	4	
	Bairdia sp. (articulated, various sizes)	3P	
	Moorites sp. (articulated, various sizes)	2	
	Crinoid debris (columnals)	28	
	Echinoid debris (internal plate)	1	
	Holothurian debris (sclerites)	2	
	Ophiuroid and/or Asteroid debris (ossicles)	3	
	Cavusgnathodus sp.	1	
	Fish debris (denticles?)	1	
	Total		4.4
Note:	Float sample G-11S collected from the interval represented by beds G-14 (upper 3.4'), G-15 and the lower 1.5' of G-16.		
G-17	Alternating bands of dark yellowish orange (10YR6/6) and light brown (5YR5/6) fresh, moderate brown (5YR4/4) to light brown (5YR5/6) weathered, soft, slightly		

Section G--Continued

Bed	Description	Thickness (feet)
G-17--(Continued)	calcareous, concentrically banded ironstone concretions with soft powdery, grayish orange (10YR7/4) centers. These concretions form a discontinuous, non-fossiliferous, undulatory horizon. Sample G-12B. Total	<0.1
G-18	Claystone as below at bed G-16. More mottled appearance with the grayish orange (10YR7/4) colors, much less calcareous, more carbonaceous, silty and containing large (6x4x1.5 cm.) ironstone concretions and nodules as below at beds G-17 and G-13 respectively. Calcareous nodules of lower beds (G-12, G-14, and G-16) are absent. Sample G-12C; Washed residue: *Ammodiscus* sp. — 1P *Bathysiphon* sp. — 2P *Earlandinita* sp. — 6 *Lituotuba* sp. — 3 *Reophax* sp. (tests composed of mica flakes) — 5 *Mesolobus euampygus* (fragments) — 3 *Bairdia* sp. (articulated, various sizes) — 6 Crinoid debris (columnals) — 12P Echinoid debris (spines) — 5 Ophiuroid and/or Asteroid debris (ossicles) — 1 Total	1.1
G-19	Horizon of ironstone nodules as below at bed G-13 with exterior mottled with a moderate reddish brown (10R4/6) color. Sample G-12D. Total	<0.1
G-20 (lower 0.8')	Yellowish gray (5Y7/2) to light olive gray (5Y6/1) and greenish gray (5GY6/1) fresh, lighter shades of these colors weathered, platy to "crumbly" and slightly blocky, highly micaceous and carbonaceous, very slightly calcareous, sparsely fossiliferous,	

Section G--Continued

Bed	Description	Thickness (feet)
G-20--(Continued)		
	ferruginous, silty claystone with large ironstone nodules as described for bed G-13 below.	
	Mica is very abundant and occurs in larger flakes as does the carbonaceous material.	
	Sample G-12E; Washed residue:	
	Ammobaculites sp. — 1	
	Ammodiscus sp. — 5P	
	Bathysiphon sp. — 3P	
	Earlandinita sp. — 2P	
	Reophax sp. (tests composed of mica flakes) — 2	
	Mesolobus decipiens (articulated & fragments) — 13	
	Bairdia sp. (articulated, various sizes) — 3	
	Crinoid debris (columnals) — 2	
	Holothurian debris (sclerites) — 1	
	Carbonaceous fragments — 1P	
	Quartz grains of very fine sand size — 1P	
	Mica flakes — 6P	
	Total	0.8
Note:	Float sample G-12S was collected from the interval represented by beds G-16 (upper 2.9'), G-17, G-18, G-19 and the lower 0.8' of G-20.	
G-20 (middle 5.0')	Claystone as below, lower 0.8' of bed G-20. Samples from Stations G-824.0' and G-825.0' were collected from this interval. Float sample G-13S collected from this interval at bed G-20.	
	Sample G-13; Washed residue:	
	Ammodiscus sp. — 4P	
	Bathysiphon sp. — 2P	
	Earlandinita sp. — 1P	
	Reophax sp. (test of mica flakes) — 1	
	Mesolobus decipiens (articulated, various sizes) — 11	
	Mesolobus euampygus (articulated, various sizes) — 3	
	Productoid and/or chonetoid spines — 2	
	Bairdia sp. (articulated, various sizes) — 2	
	Crinoid debris (columnals) — 4P	
	Echinoid debris (spine) — 1	

Section G--*Continued*

Bed	Description		Thickness (feet)
G-20--(*Continued*)			
	?Scolecodonts (fragments)	3	
	Ozarkodina sp. (fragment)	1	
	Carbonaceous fragments	1P	
	Mica flakes	5P	
	Quartz grains, very fine to fine sand size, subrounded to subangular	10P	
	Total		5.0
G-20 (upper 5.0')	Claystone as below, lower 0.8' of bed G-20. Mottled with light brown (5YR5/6) and dark yellowish orange (10YR6/6) colors, more blocky, non-calcareous, and abundantly micaceous and carbonaceous. Top covered.		
	Sample G-14; Washed residue:		
	Ammodiscus sp.	2P	
	Bathysiphon sp.	1P	
	Earlandinita sp.	<1P	
	Reophax sp. (tests of mica flakes)	2	
	Inarticulate brachiopod (fragment possibly *Lingula* sp.)	1	
	Mesolobus euampygus (fragment)	1	
	Productoid and/or chonetoid spines	2	
	Bairdia sp. (articulated, various sizes)	3	
	Crinoid debris (columnals)	13	
	Carbonaceous fragments	2P	
	Mica flakes	7P	
	Quartz grains, very fine to fine sand size, subrounded to subangular	15P	
	Total		5.0
G-21	Covered, probably interbedded, sandstone, siltstones and claystones.		
	Total		14.8
G-22	Yellowish gray (5Y8/1) to very pale orange (10YR8/2) mottled with pale yellowish orange (10YR8/6) to dark yellowish orange (10YR6/6) fresh, dark yellowish brown (10YR4/2) weathered, fine to very fine sand size, fairly well sorted, subangular to subrounded, ferruginous, soft to moderately soft, poorly cemented		

Section G--Continued

Bed	Description	Thickness (feet)
G-22--(Continued)	(friable), thin to thick irregularly bedded quartz sandstone. Plant debris and impressions are present and cross bedding (small and large scale) is obvious. Top and base covered. Sample G-15.	
	Total	4.0
G-23	Covered, probably sandstone as below (bed G-22).	
	Total	9.7
G-24	Sandstone as below (bed G-22). Massive to thick beds at the base with thin, irregular beds at the top. Top and base covered.	
	Total	5.0
G-25	Covered, probably sandstone as below (G-22).	
	Total	6.5+
	TOTAL THICKNESS	110.0+

Section H

Starts at an elevation of 758.1', ±9.0'W. and ±5.0'S. of the C. of N. line, NE$\frac{1}{4}$, SE$\frac{1}{4}$, NE$\frac{1}{4}$, NE$\frac{1}{4}$, NE$\frac{1}{4}$, NE$\frac{1}{4}$, Sec. 32., T. 7 N., R. 9 E., and ends at an elevation of 778.7' near the C. of the W. line of SW$\frac{1}{4}$, NW$\frac{1}{4}$, NW$\frac{1}{4}$, NW$\frac{1}{4}$, NW$\frac{1}{4}$, NW$\frac{1}{4}$, Sec. 33., T. 7 N., R. 9 E., Hughes County, Oklahoma. In terms of the three reference points the top is: 2517.0' due North of point 1, 1848.0' N.45°30'W. of point 2 and 1777.0' N.47°30'W. of point 3; the base is: 2464.0' N.1°0'W. of point 1, 1850.0' N.47°30'W. of point 2 and 1780.0' N.50°10' W. of point 3.

Measured in the bank on the east side of the permanent stream. Start at an elevation of 758.1' (water level, fall, 1968) 64.6' N.33°0'W.

Section H--Continued

of the base of Section G; measure (beds H-1 through the lower 3.3' of H-6) 11.2' vertically and 25.0' horizontally S.87°0'E. to an elevation of 769.3'; continue measuring (remainder of beds) 9.4' vertically and 60.0' horizontally N.28°30'E. to the east side of an old farm road (trends approximately north-south) at an elevation of 778.7'.

Bed	Description	Thickness (feet)

H-1 Medium gray (N-4) fresh, medium gray (N-5), to medium light gray (N-6), hard, pyritic, carbonaceous, slightly micaceous, fissile to slightly platy, fossiliferous shale.

Pyrite occurs as small bodies and stains on the bedding planes.

Sample H-1; Washed residue:

Ammodiscus sp.	10P
Anthraconeilo taffiana (articulated)	1
Trepospira depressa	2
Gastrioceras sp. (pyritized)	1
Scolecodont	1
Hindeodellids (fragments)	2
Idiognathodus sp. (abraded, recycled?)	1
Ozarkodina sp. (fragment)	1
?Streptognathodus sp.	2
Fish debris	1
Faecal pellets	<1P

Total 0.2+

H-2 Light olive gray (5Y6/1) to medium light gray (N-6) fresh, dark yellowish brown (10YR4/2) to moderate brown (5YR3/4), soft to moderately hard, pyritic, discontinuous, non-fossiliferous nodules of iron oxide (goethite). Originally may have been siderite.

Pyrite occurs as irregular masses suggesting burrows.

Similar to the lowest bed in Section F (F-1).

Sample H-2.

Total 0.2

H-3 Shale as below at bed H-1 with light olive gray (5Y6/1) to dusky yellow (5Y6/4) and dark yellowish

Section H--Continued

Bed	Description	Thickness (feet)

H-3--(Continued)

orange (10YR6/6) calcareous, argillaceous, non-fossiliferous ironstone nodules.

Sample H-3A; Washed residue:

Ammodiscus sp.	<1P
Bathysiphon sp.	<1P
?Reophax sp.	1
Pelecypod (unidentifiable, internal mold)	1
Goniatite (small ?Gastrioceras sp.)	1
Hindeodellids (fragment)	1
Ozarkodina (fragment)	1
Faecal pellets	1
Fish debris	1
Pyritic bodies	2P

Total 0.5

H-4 Shale as below at bed H-3 without ironstone nodules. Light brown (5YR5/6), moderate brown (5YR4/4) and (5YR3/4), moderate yellow (5Y7/6) and pale yellowish orange (10YR8/6) stains on the bedding planes.

Sample H-3; Washed residue:

Ammodiscus sp.	<1P
Bathysiphon sp.	<1P
?Coral	1
Crurithyris planoconvexa (articulated)	1
Hindeodellid (fragment)	1
Ozarkodina sp.	1
Fish debris	1
Faecal pellets	1
Pyritic masses	2P

Total 4.5

H-5 Shales as below at bed H-4 interbedded and interlaminated with medium gray (N-5) to dull light olive gray (5Y6/1) fresh, lighter shades of these colors weathered, soft, blocky to platy, slightly calcareous, micaceous, carbonaceous, fossiliferous claystone. Scattered ironstone nodules, as in bed H-4 below, in the upper part. This is a transitional unit between the shale below and claystone above.

Section H--Continued

Bed	Description		Thickness (feet)
H-5--(Continued)			
	Sample H-4; Washed residue:		
	Ammobaculites sp.	<1P	
	Ammodiscus sp.	2P	
	Bathysiphon sp.	1P	
	Earlandinita sp.	1P	
	Endothyranella sp.	1	
	Lituotuba sp.	2P	
	Reophax sp.	1P	
	Tolypammina sp. (epizoans)	5	
	Lingula cf. *L. carbonaria* (articulated)	1	
	Crurithyris planoconvexa (articulated & disarticulated, various sizes)	9	
	Mesolobus decipiens (immature)	4	
	Plagioglypta sp. (broken specimen)	2	
	Anthraconeilo taffiana (articulated, various sizes)	7	
	Astartella cf. *A. concentrica* (articulated)	1	
	Nuculopsis girtyi (articulated)	1	
	Nuculopsis (*P.*) *anodontoides* (articulated, immature)	5	
	Nuculopsis (*P.*) *wewokana* (articulated, immature)	6	
	Glabrocingulum (*A.*) *grayvillensis* (various sizes)	10	
	Ianthinopsis sp. (immature)	3	
	Meekospira peracuta (various sizes, broken)	5	
	Trepospira depressa (various sizes)	8	
	Pseudorthoceras sp. (broken specimen)	2	
	Metacoceras sp. (broken)	1	
	Goniatites (small)	12	
	Bairdia sp. (articulated, various sizes)	3P	
	Healdia sp. (articulated, various sizes)	2	
	Crinoid debris (columnals)	6	
	Echinoid debris (spines and pedicellaria)	7	
	Holothurian debris (sclerites)	2	
	Ophiuroid and/or Asteroid debris (ossicles)	5	
	Scolecodonts	2	
	Gnathodus sp.	1	
	Hindeodellid (fragment)	1	
	Idiognathodus sp.	2	
	Ozarkodina sp.	1	
	Fish debris	2	
	Plant debris	6	
	Faecal pellets	15P	
	Total		2.5

Section H--Continued

Bed	Description	Thickness (feet)
H-6 (lower 4.5')	Claystone as below at bed H-5 with ironstone nodules of light brown (5YR5/6) to dark yellowish orange (10YR6/6), calcareous, generally rather small (10-15 mm. in diameter and 5-8 mm. thick). Contact with underlying bed (H-5) is gradational. Float sample H-7 collected from this interval.	

Samples H-5 and H-6; Washed residues:

Ammobaculites sp.	<1P
Ammodiscus sp.	2P
Bathysiphon sp.	1P
Earlandinita sp.	1P
Endothyranella sp.	1
Lituotuba sp.	2P
Reophax sp.	1P
Tolypammina sp. (epizoans)	6
Lingula cf. L. carbonaria (articulated)	4
Lindstroemella cf. L. patula	1
Crurithyris planoconvexa (articulated & disarticulated, various sizes)	15
Mesolobus decipiens (articulated)	6
Plagioglypta sp. (broken specimen)	3
Anthraconeilo taffiana (articulated, various sizes)	11
Nuculopsis girtyi (articulated)	2
Nuculopsis (P.) anodontoides (articulated, immature)	5
Nuculopsis (P.) wewokana (articulated, various sizes)	6
Paleyoldia glabra (articulated)	1
Polidevica bellistriata (articulated)	5
Euphemites carbonarius	3
Euphemites carbonarius	3
Glabrocingulum (A.) grayvillensis (various sizes)	22
Ianthinopsis sp.	3
Meekospira peracuta	7
Pseudozygopleurids	2
Trepospira depressa (various sizes)	25
Cycloceras sp. (broken)	2
Goniatites (small)	
Bairdia sp. (articulated, various sizes)	3P
Healdia sp. (articulated, various sizes)	2
Crinoid debris (columnals)	5
Aggregate of crinoid brachials	1
Echinoid debris (spines & plates)	10
Holothurian debris (sclerites)	3

Section H--Continued

Bed	Description		Thickness (feet)
H-6--(Continued)			
	Ophiuroid and/or Asteroid debris (ossicles)	9	
	?Scolecodonts	1	
	Hindeodellids (fragments)	3	
	Fish debris	2	
	Faecal pellets	10P	
	Total		4.5
H-6 (upper 5.0')	Claystone as below at bed H-6 (lower 4.5'). Samples of Station H-773.0' and float sample H-8A were collected from this interval.		
	Sample H-8; Washed residue:		
	Ammobaculites sp.	<1P	
	Ammodiscus sp.	1P	
	Bathysiphon sp.	1P	
	Earlandinita sp.	1P	
	Endothyranella sp.	8	
	Lituotuba sp.	2P	
	Reophax sp.	1P	
	Tolypammina sp. (epizoans)	6	
	Lingula cf. *L. carbonaria* (articulated)	4	
	Lindstroemella cf. *L. patula*	1	
	Crurithyris planoconvexa (articulated, various sizes)	6	
	Mesolobus decipiens (articulated)	6	
	Plagioglypta sp. (broken specimen)	3	
	Anthraconeilo taffiana (articulated, various sizes)	9	
	Nuculopsis (*P.*) *anodontoides* (articulated, various sizes)	5	
	Nuculopsis (*P.*) *wewokana* (articulated, various sizes)	6	
	Polidevica bellistriata (articulated, various sizes)	3	
	Euphemites carbonarius (various sizes)	4	
	Glabrocingulum (*A.*) *grayvillensis* (various sizes)	18	
	Ianthinopsis sp.	3	
	Meekospira peracuta (immature)	4	
	Pseudozygopleurids	2	
	Trepospira depressa (various sizes)	10	
	Goniatites (small)	10	
	Trilobite debris	1	

Section H--Continued

Bed	Description		Thickness (feet)
H-6--(Continued)			
	Ostracodes (unidentified, articulated)	1P	
	Crinoid debris (columnals)	6	
	Echinoid debris (spines)	5	
	Holothurian debris (sclerites)	3	
	Ophiuroid and/or Asteroid debris (ossicles)	8	
	Unidentifiable conodont	1	
	Faecal pellets	9P	
		Total	5.0
H-7	Covered, probably claystone.		
		Total	1.8
H-8	Yellowish brown, "crumbly" soil with ironstone nodules. No sample collected.		
		Total	1.4+
		TOTAL THICKNESS	20.6+

APPENDIX II

LOCATION OF THE 19 COLLECTING STATIONS

Contained in this section are the geographic and stratigraphic locations of the 19 collecting stations. Fossil assemblages from these 19 stations provided the basis for construction of the communities.

The letter prefix refers to the measured section, in the vicinity of which the sampling station was located. The numerical value after the letter is the elevation above sea level from which the sample was taken (stratigraphic position). Horizons are referred to by roman numerals, I the lowest through V the highest. For example, F-776.8' HORIZON I indicates that the station was at or near measured section F at an elevation of 776.8' above sea level and the HORIZON I means it is stratigraphically the lowest level sampled. The roman numeraled horizons are equivalent levels in the various measured sections based on a dip of one degree determined by Weaver, 1954, p. 60.

Some of the stations are loçated in the line of the measured section and are so indicated. Others are not, but are positioned with respect to the ones that are by horizontal distances and bearings. All stations are located in terms of horizontal distances and bearings from the three points defined in section titled Selection of the Stratigraphic Unit and Field Methods page 25.

F-776.8' HORIZON I (in line of measured section)

2264.0' N. 2°30'E. of point 1
1600.0' N.49° 0'W. of point 2
1533.0' N.52°15'W. of point 3

G-774.7' HORIZON I (in line of measured section)

2425.0' N. 1°15'E. of point 1
1745.0' N.46°30'W. of point 2
1676.0' N.49° 0'W. of point 3

H-773.0' HORIZON I (in line of measured section)

2476.0' N 0°30'W. of point 1
1835.0' N.47°0'W. of point 2
1766.0' N.50°0'W. of point 3

C-796.2' HORIZON II (in line of measured section)

1453.0' N.25°35'E. of point 1
694.0' N.81°45'W. of point 2
689.0' N.89° 0'W. of point 3

E-793.0' HORIZON II (in line of measured section)

2124.0' N.18°30'E. of point 1
1020.0' N.39°15'W. of point 2
940.0' N.43° 0'W. of point 3

F-781.7' HORIZON II (in line of measured section)

2240.0' N. 5°30'E. of point 1
1539.0' N.48°30'W. of point 2
1472.0' N.51°30'W. of point 3

F-782.4' HORIZON II (63.5' N.65°E. of Station F-781.7')

2270.0' N. 5°30'E. of point 1
1512.0' N46°15'W. of point 2
1445.0' N.49° 0'W. of point 3

C-803.7' HORIZON III (in line of measured section)

1434.0' N.25°30'E. of point 1
704.0' N.83°30'W. of point 2
700.0' S.88° 0'W. of point 3

E-800.5' HORIZON III (in line of measured section)

2280.0' N.20°30'E. of C. of West line, Sec. 33, T. 7 N.,R. 9 E.
1046.0' N.29°30'W. of C. of W.P.A. Dam
958.0' N.32°30'W. of C. of NW¼, Sec. 33, T. 7 N., R. 9 E.

F-789.9' HORIZON III (93.0' N.40°30'W. of Station F-791.2')

2372.0' N. 4°45'E. of C. of West line, Sec. 33, T. 7 N., R. 9 E.
1590.0' N.44°15'W. of C. of W.P.A. Dam
1519.0' N.46°30'W. of C. of NW¼, Sec. 33, T. 7 N., R. 9 E.

F-791.2' HORIZON III (in line of measured section)

2310.0' N. 6°30'E. of C. of West line, Sec. 33, T. 7 N., R. 9 E.
1498.0' N.44°W. of C. of W.P.A. Dam
1427.0' N.47°W. of C. of NW¼, Sec. 33, T. 7 N., R. 9 E.

E-826.0' HORIZON IV (in line of measured section)

2439.0' N.18°30'E. of C. of West line, Sec. 33, T. 7 N., R. 9 E.
1220.0' N.26°30'W. of C. of W.P.A. Dam
1126.0' N.29° W. of C. of NW¼, Sec. 33, T. 7 N., R. 9 E.

E-827.2' HORIZON IV (63.0' S.82°E. of Station E-826.0')

2450.0' N.19°45'E. of C. of West line, Sec. 33, T. 7 N., R. 9 E.
1186.0' N.24°W. of C. of W.P.A. Dam
1095.0' N.26°30'W. of C. of NW¼, Sec. 33, T. 7 N., R. 9 E.

G-815.1' HORIZON IV (45.5' N.63°W. of Station G-816.0')

2550.0' N.4°E. of C. of West line, Sec. 33, T. 7 N., R. 9 E.
1729.0' N.40°30'W. of C. of W.P.A. Dam
1650.0' N.42°30'W. of C. of NW¼, Sec. 33, T. 7 N., R. 9 E.

G-816.0' HORIZON IV (in line of measured section)

2540.0' N.5°30'E. of C. of West line, Sec. 33, T. 7 N., R. 9 E.
1695.0' N.39°30'W. of C. of W.P.A. Dam
1616.0' N.41°30'W. of C. of NW¼, Sec. 33, T. 7 N., R. 9 E.

E-835.0' HORIZON V (39.5' S.68°W. of Station E-835.5')

2470.0' N.18°45'E. of C. of West line, Sec. 33, T. 7 N., R. 9 E.
1240.0' N.25°W. of C. of W.P.A. Dam
1146.0' N.27°30'W. of C. of NW¼, Sec. 33, T. 7 N., R. 9 E.

E-835.5' HORIZON V (in line of measured section)

2495.0' N.19°30'E. of point 1
1235.0' N.23° 0'W. of point 2
1140.0' N.25°30'W. of point 3

G-824.0' HORIZON V (62.5' N.54°W. of Station G-825.0')

2570.0' N. 4°30'E. of point 1
1740.0' N.39°30'W. of point 2
1661.0' N.41°30'W. of point 3

G-825.0' HORIZON V (in line of measured section)

2543.0' N. 6° 0'E. of point 1
1682.0' N.39° 0'W. of point 2
1605.0' N.41° 0'W. of point 3

APPENDIX III

NATURE OF THE 19 FOSSIL ASSEMBLAGES

The nature and composition of the 19 fossil assemblages is contained in this section. Locality notations are explained in Appendix II and indicate geographic and stratigraphic location.

Column one is the taxonomic entity, these are arranged alphabetically by phyla for each collecting station, i.e., Protozoa, Porifera, Coelenterata, etc. A double asterisk (**) behind any taxonomic entity indicates that adequate specimens (individuals) were recovered to permit the construction of a size-frequency distribution.

Column two gives the total number of individuals (specimens) of each taxonomic entity. For colonial organisms, such as bryozoa, this number refers to the number of specimens not the number of individuals. Numbers followed by # were not considered when the total number of individuals (specimens) were counted to obtain the percentage each taxonomic entity contributed to the total (column three). Numbers so marked always refer to the number of fragments, i.e., trilobite, productoid, echinoderm, etc. Since these numbers were not used in calculating column 3, percentage of individuals, no value appears in this column for those entities.

Columns 4, 5, and 6 indicate the percentage of articulation of the bivalves, percentage of disarticulated valves and percentage of broken (NOT CRUSHED) specimens. The percentage of disarticulated valves is reported as % BV (brachial valves of brachiopods) and % LV (left valves of pelecypods). Dashes in these columns mean that they do not apply to that particular entity (i.e., columns 4 and 5 for gastropods) or that no attempt was made, as column 6 for the foraminifers.

Column six indicates the percentage of disarticulation of the skeleton for all the echinoderms and trilobites. For all other forms it refers to broken specimens. An asterisk (*) in these last three columns indicates that there were less than 10 individuals (specimens) for that particular entity and hence no attempt was made to determine the values. A query (?) by any figure indicates it is a questionable value and alone means that it was not possible to obtain an accurate value.

Blank spaces in the various columns are self-explanatory.

LOCALITY F-776.8'   HORIZON I

Taxonomic Entity	Total No. of Indiv.	Percent of Indiv.	Percent Artic.	Percent BV or LV	Percent Broken
Ammobaculites sp.	1152	4.57	-	-	-
Ammodiscus sp.	3392	13.47	-	-	-
Bathysiphon sp.	2208	8.77	-	-	-
Earlandinita sp.	1024	4.07	-	-	-
Endothyranella sp.	2112	8.39	-	-	-
Lituotuba sp.	512	2.03	-	-	-
Reophax sp.	1088	4.32	-	-	-
Tolypammina sp.	288	1.14	-	-	-
Lingula cf. L. carbonaria**	320	1.27	100.0		0.0
Lindstroemella cf. L. patula	2	0.0079	*	*	*
Crurithyris planoconvexa**	826	3.28	81.8	22.2	53.3
Mesolobus euampygus**	68	0.27	100.0		0.0
Plagioglypta sp.**	905	3.59	-	-	100.0
Anthraconeilo taffiana**	687	2.73	100.0		53.2
Nuculopsis (Palaeonucula) anodontoides**	394	1.56	100.0		60.0
Nuculopsis (Palaeonucula) wewokana**	1124	4.46	85.7	50.0	0.0
Nuculopsis girtyi	1	0.004	*	*	*
Paleyoldia glabra	67	0.27	100.0		100.0
Polidevica bellistriata**	72	0.29	90.2	50.0	55.0
Bellerophon (B.) cf. B. (B.) crassus	2	0.0079	-	-	*
Euphemites carbonarius**	391	1.55	-	-	0.0
Glabrocingulum (A.) grayvillensis**	2533	10.06	-	-	67.4
Ianthinopsis sp.**	610	2.42	-	-	0.0
Girtyspira sp.	64	0.25	-	-	0.0
Meekospira peracuta**	1033	4.10	-	-	87.8
Pseudozygopleurids**	768	3.05	-	-	0.0
Trepospira depressa**	2146	8.52	-	-	63.6
Pseudorthoceras sp.	5	0.02	-	-	*
Gastrioceras sp.	940	3.73	-	-	16.7'

LOCALITY F-776.8' HORIZON I--(Concluded)

Taxonomic Entity	Total No. of Indiv.	Percent of Indiv.	Percent Artic.	Percent BV or LV	Percent Broken
<u>Bairdia</u> sp.	128	0.51	100.0		0.0
<u>Healdia</u> sp.	320	1.27	100.0		0.0
Crinoid debris	1191#				100.0
Echinoid debris	260#				100.0
Holothurian debris	256#				100.0
Ophiuroid and/or Asteroid debris	992#				100.0
<u>Idiognathodus</u> sp	256#				
Other Conodonts	192#				
Fish debris	320#				
Faecal pellets	16,384#				

LOCALITY G-774.7'

HORIZON I

Taxonomic Entity	Total No. of Indiv.	Percent of Indiv.	Percent Artic.	Percent BV or LV	Percent Broken
Ammodiscus sp.	3872	14.83	-	-	-
Bathysiphon sp.	1152	4.41	-	-	-
Earlandinita sp.	896	3.43	-	-	-
Endothyra sp.	128	0.49	-	-	-
Endothyranella sp.	3104	11.89	-	-	-
Fusulina sp.	48	0.18	-	-	-
Reophax sp.	768	2.94	-	-	-
Tolypammina sp.	256	0.98	-	-	-
Ramose Bryozoa	69	0.26	-	-	100.0
Conularia cf. C. crustula	1	0.0038	-	-	*
Lingula cf. L. carbonaria	32	0.12	100.0		100.0?
?Cleiothyridina sp.	16	0.06	100.0		0.0
Crurithyris planoconvexa**	667	2.55	66.7	25.0	60.0
Mesolobus decipiens	34	0.13	50.0	100.0	50.0
Mesolobus euampygus**	41	0.16	55.5	75.0	66.7
Plagioglypta sp.**	1926	7.38	-	-	100.0
Anthraconeilo taffiana**	599	2.29	100.0		42.8
Astartella cf. A. concentrica	32	0.12	100.0		100.0
Nuculopsis (Palaeonucula) anodontoides**	1763	6.75	100.0		66.7
Nuculopsis (Palaeonucula) wewokana**	1108	4.24	80.0	66/7	0.0
Paleyoldia glabra	3	0.01	*	*	*
Polidevica bellistriata**	46	0.18	93.1	50.0	32.3
Euphemites carbonarius**	900	3.45	-	-	50.0
Girtyspira sp.	96	0.37	-	-	0.0
Glabrocingulum (A.) grayvillensis**	2325	8.90	-	-	56.0
Ianthinopsis sp.**	676	2.59	-	-	33.3

LOCALITY G-774.7' HORIZON I--(Concluded)

Taxonomic Entity	Total No. of Indiv.	Percent of Indiv.	Percent Artic.	Percent BV or LV	Percent Broken
Meekospira peracuta**	484	1.85	-	-	100.0
Pseudozygopleurids**	1425	5.46	-	-	0.0
Trepospira depressa**	2341	8.97	-	-	49.0
Pseudorthoceras sp.	19	0.07	-	-	100.0
Gastrioceras sp.	259	0.99	-	-	33.3
Ditomoypge sp. fragments	32#				100.0
Amphissites sp.	483	1.47	100.0		0.0
Bairdia sp.	256	0.98	100.0		0.0
Cavellina sp.	256	0.98	100.0		0.0
Healdia sp.	128	0.49	100.0		0.0
Crinoid debris	1879#				100.0
Echinoid debris	2646#				100.0
Holothurian debris	896#				100.0
Ophiuroid and/or Asteroid debris	736#				100.0
Fish debris	32#				
Faecal pellets	160#				

LOCALITY H-773.0'   HORIZON I

Taxonomic Entity	Total No. of Indiv.	Percent of Indiv.	Percent Artic.	Percent BV or LV	Percent Broken
Ammobaculites sp.	832	3.57	-	-	-
Ammodiscus sp.	1024	4.44	-	-	-
Earlandinita sp.	256	1.11	-	-	-
Endothyranella sp.	1920	8.32	-	-	-
Lituotuba sp.	128	0.55	-	-	-
Reophax sp.	1920	8.32	-	-	-
Tolypammina sp.	208	0.90	-	-	-
Ramose Bryozoa	64	0.28	-	-	100.0
Lingula cf. L. carbonaria**	448	1.94	100.0		50.0
Lindstroemella cf. L. patula	2	0.0087	*	*	*
Cleiothyridina sp.	1	0.0043	*	*	*
Crurithyris planoconvexa**	936	4.06	66.7	10.0	58.3
Mesolobus decipiens**	20	0.09	100.0		75.0
Productoid fragments	64#				
Plagioglypta sp.**	1296	5.62	-	-	100.0
Anthraconeilo taffiana**	1984	8.60	92.9	0.0	50.0
Nuculopsis (Palaeonucula) anodontoides**	930	4.03	100.0		0.0
Nuculopsis (Palaeonucula) wewokana**	1508	6.54	84.2	66.7	0.0
Nuculopsis girtyi	33	0.14	100.0		0.0
Paleyoldia glabra	3	0.013	*	*	*
Polidevica bellistriata**	115	0.50	86.4	100.0	47.4
Bellerophon (B.) cf. B. (B.) crassus	128	0.55	-	-	25.0
Euphemites carbonarius**	724	3.14	-	-	62.9
Glabrocingulum (A.) grayvillensis**	3248	14.08	-	-	100.0
Ianthinopsis sp.**	272	1.18	-	-	0.0
Meekospira peracuta**	660	2.86	-	-	100.0
Pseudozygopleurids	256	1.11	-	-	64.5
Trepospira depressa**	3382	14.66	-	-	64.5

LOCALITY H-773.0'   HORIZON I--(Concluded)

Taxonomic Entity	Total No. of Indiv.	Percent of Indiv.	Percent Artic.	Percent BV or LV	Percent Broken
Pseudorthoceras sp.**	131	0.57	-	-	100.0
Gastrioceras sp.**	643	2.79	-	-	33.3
Crinoid debris	1191#				100.0
Echinoid debris	548#				100.0
Holothurian debris	896#				100.0
Ophiuroid and/or Asteroid debris	2800#				100.0
Fish debris	64#				
Faecal pellets	1424#				

LOCALITY C-796.2' HORIZON II

Taxonomic Entity	Total No. of Indiv.	Percent of Indiv.	Percent Artic.	Percent BV or LV	Percent Broken
Ammobaculites sp.	4864	13.00	-	-	-
Ammodiscus sp.	2816	7.52	-	-	-
Bathysiphon sp.	1280	3.42	-	-	-
Earlandinita sp.	1920	5.13	-	-	-
Endothyranella sp.	3328	8.89	-	-	-
Lituotuba sp.	512	1.37	-	-	-
Reophax sp.	2528	6.75	-	-	-
Sponge spicules	128#		-	-	-
Conularia cf. C. crustula	1	0.0027	-	-	*
Encrusting Bryozoa	16	0.043	-	-	100.0
Lingula cf. L. carbonaria**	416	1.11	100.0		50.0
Lindstroemella cf. L. patula	18	0.048	100.0		0.0
Crurithyris planoconvexa**	342	0.91	84.6	75.0	50.0
Mesolobus decipiens**	289	0.77	100.0		0.0
Plagioglypta sp.**	2576	6.88	-	-	100.0
Anthraconeilo taffiana**	1032	2.76	100.0		37.5
Nuculopsis (Palaeonucula) anodontoides**	304	0.81	60.0	0.0	0.0
Nuculopsis (Palaeonucula) wewokana**	2070	5.53	84.6	50.0	16.7
Polidevica bellistriata**	256	0.68	94.7	50.0	43.7
Bellerophon (B.) cf. B. (B.) crassus	128	0.34	-	-	0.0
Euphemites carbonarius**	1219	3.26	-	-	66.7
Glabrocingulum (A.) grayvillensis**	3171	8.47	-	-	62.9

LOCALITY C-796.2'   HORIZON II--(Concluded)

Taxonomic Entity	Total No.of Indiv.	Percent of Indiv.	Percent Artic.	Percent BV or LV	Percent Broken
Ianthinopsis sp.**	897	2.40	-	-	0.0
Meekospira peracuta**	683	1.82	-	-	100.0
Pseudozygopleurids**	1728	4.62	-	-	0.0
Trepospira depressa**	3040	8.12	-	-	81.3
Worthenia cf. W. tabulata	1	0.0027	-	-	*
Mooreoceras sp.	1	0.0027	-	-	*
Pseudorthoceras sp.	4	0.011	-	-	*
Gastrioceras sp.**	1217	3.25	-	-	0.0
Amphissites sp.	256	0.68	0.0	?	100.0
Healdia sp.	384	1.03	100.0		0.0
Moorites sp.	128	0.34	100.0		0.0
Crinoid debris	1265#				100.0
Echinoid debris	1744#				100.0
Holothurian debris	1426#				100.0
Ophiuroid and/or Asteroid debris	2130#				100.0
Streptognathodus sp.	128#				
Fish debris	160#				
Faecal pellets	2736#				

LOCALITY E-793.0'   HORIZON II

Taxonomic Entity	Total No. of Indiv.	Percent of Indiv.	Percent Artic.	Percent BV or LV	Percent Broken
Ammobaculites sp.	1152	2.58	-	-	-
Ammodiscus sp.	6784	15.17	-	-	-
Bathysiphon sp.	1824	4.08	-	-	-
Earlandinita sp.	1536	3.44	-	-	-
Endothyranella sp.	5856	13.10	-	-	-
?Glabovalvulina sp.	128	0.29	-	-	-
Lituotuba sp.	2176	4.87	-	-	-
Reophax sp.	2432	5.44	-	-	-
Tolypammina sp.	496	1.11	-	-	-
Sponge spicules	32#		-	-	-
Lingula sp. fragments	640	1.43	-	-	100.0
Lindstroemella cf. L. patula	3	0.0067	*	*	*
Crurithyris planoconvexa**	2055	4.60	77.9	25.0	50.5
Mesolobus euampygus**	323	0.72	100.0		0.0
Plagioglypta sp.**	2233	4.99	-	-	100.0
Allorisma sp.	1	0.0022	*	*	*
Anthraconeilo taffiana**	2295	5.13	100.0		26.1
Nuculopsis (Palaeonucula) anodontoides**	1319	2.95	100.0		28.6
Nuculopsis (Palaeonucula) wewokana**	1439	3.22	89.5	100.0	14.3
Nuculopsis girtyi	19	0.042	100.0		0.0
Paleyoldia glabra	2	0.0045	*	*	*
Polidevica bellistriata**	601	1.34	100.0		39.0
Euphemites carbonarius**	1061	2.37	-	-	0.0
Girtyspira sp.	32	0.071	-	-	0.0
Glabrocingulum (A.) grayvillensis**	4108	9.19	-	-	65.7
Ianthinopsis sp.**	418	0.93	-	-	0.0
Meekospira peracuta**	676	1.51	-	-	85.0
Pseudozygopleurids**	688	1.54	-	-	0.0

LOCALITY E-793.0' HORIZON II--(Concluded)

Taxonomic Entity	Total No. of Indiv.	Percent of Indiv.	Percent Artic.	Percent BV or LV	Percent Broken
*Trepospira depressa***	3017	6.75	-	-	74.4
Pseudorthoceras sp.	20	0.045	-	-	100.0
Gastrioceras sp.**	838	1.87	-	-	100.0
Bairdia sp.	384	0.86	100.0		0.0
Healdia sp.	160	0.36	100.0		0.0
Crinoid debris	1202#				100.0
Echinoid debris	1684#				100.0
Holothurian debris	1408#				100.0
Ophiuroid and/or Asteroid debris	1744#				100.0
Scolecodonts	256#				
Gnathodus sp.	32#				
Hindeodellids	128#				
Other Conodonts	128#				
Faecal pellets	832#				

LOCALITY F-781.7' HORIZON II

Taxonomic Entity	Total No. of Indiv.	Percent of Indiv.	Percent Artic.	Percent BV or LV	Percent Broken
Ammobaculites sp.	1728	6.41	-	-	-
Ammodiscus sp.	1280	4.75	-	-	-
Bathysiphon sp.	1480	5.49	-	-	-
Earlandinita sp.	256	0.95	-	-	-
Endothyranella sp.	2304	8.54	-	-	-
Lituotuba sp.	640	2.37	-	-	-
Reophax. sp.	640	2.37	-	-	-
Lophophyllum cf. L. profundum	21	0.079	-	-	95.2
Lingula cf. L. carbonaria	384	1.42	?	?	100.0
Lindstroemella cf. L. patula	2	0.0074	*	*	*
Crurithyris planoconvexa**	64	0.24	78.8	0.0	46.9
Mesolobus decipiens	1	0.0037	*	*	*
Plagioglypta sp.**	4704	17.44	-	-	100.0
Anthraconeilo taffiana**	1652	6.13	100.0		40.0
Astartella cf. A. concentrica	3	0.011	*	*	*
Nuculopsis (Palaeonucula) wewokana**	1766	6.59	100.0		0.0
Paleyoldia glabra	4	0.015	*	*	*
Polidevica bellistriata**	155	0.57	96.7	0.0	35.6
Euphemites carbonarius**	1413	5.24	-	-	40.0
Girtyspira sp.	32	0.12	-	-	0.0
Glabrocingulum (A.) grayvillensis**	3088	11.45	-	-	61.7
Ianthinopsis sp.**	1025	3.80	-	-	0.0
Knightites (Cymatospira) cf. K. (C.) montfortianum	1	0.0037	-	-	*
Meekospira peracuta**	1334	4.95	-	-	100.0
Pseudozygopleurids**	1152	4.27	-	-	0.0
Trepospira depressa**	1387	5.14	-	-	57.9
Pseudorthoceras sp.	2	0.0074	-	-	*
Gastrioceras sp.	452	1.67	-	-	50.0

LOCALITY F-781.7'   HORIZON II--(Concluded)

Taxonomic Entity	Total No. of Indiv.	Percent of Indiv.	Percent Artic.	Percent BV or LV	Percent Broken
Trilobites fragments	32#				100.0
Crinoid debris	1123#				100.0
Echinoid debris	3421#				100.0
Holothurian debris	896#				100.0
Ophiuroid and/or Asteroid debris	1632#				100.0
Scolecodonts	128#				
Gnathodus sp.	128#				
Other conodonts	128#				
Faecal pellets	13,824#				

LOCALITY F-782.4'　　　　HORIZON II

Taxonomic Entity	Total No. of Indiv.	Percent of Indiv.	Percent Artic.	Percent BV or LV	Percent Broken
Ammobaculites sp.	3232	15.50	-	-	-
Ammodiscus sp.	256	1.23	-	-	-
Bathysiphon sp.	320	1.53	-	-	-
Earlandinita sp.	768	3.68	-	-	-
Endothyranella sp.	2688	12.89	-	-	-
Reophax sp.	736	3.53	-	-	-
Tolypammina sp.	32	0.15	-	-	-
Lophophyllum cf. L. profundum	3	0.014	-	-	*
Lingula cf. L. carbonaria	544	2.61	?	?	50.0
Lindstroemella cf. L. patula	2	0.0096	*	*	*
Crurithyris planoconvexa**	740	3.55	88.5	0.0	30.5
Marginiferid fragments	4	0.0019	*	*	*
Mesolobus decipiens**	113	0.54	100.0		0.0
Other Productoid fragments	64#				
Plagioglypta sp.**	1633	7.83	-	-	100.0
Anthraconeilo taffiana**	925	4.43	100.0		55.0
Myalinid fragment	1	0.0050	*	*	*
Nuculopsis (Palaeonucula) anodontoides**	679	3.25	94.4	0.0	57.1
Nuculopsis (Palaeonucula) wewokana**	960	4.60	96.9	100.0	6.3
Paleyoldia glabra	6	0.029	*	*	*
Polidevica bellistriata**	188	0.90	96.8	0.0	64.3
Euphemites carbonarius**	664	3.18	-	-	0.0
Girtyspira sp.	16	0.077	-	-	100.0
Glabrocingulum (A.) grayvillensis	1986	9.52	-	-	63.3
Ianthinopsis sp.**	576	2.76	-	-	50.0
Knightites (Cymatospira) cf. K. (C.) montfortianum	1	0.0050	-	-	*
Meekospira peracuta**	805	3.86	-	-	9.5
Pseudozygopleurids**	547	2.62	-	-	0.0
Trepospira depressa**	2015	9.66	-	-	63.3

LOCALITY F-782.4' HORIZON II--(Concluded)

Taxonomic Entity	Total No. of Indiv.	Percent of Indiv.	Percent Artic.	Percent BV or LV	Percent Broken
Pseudorthoceras sp.	17	0.081	-	-	100.0
Gastrioceras sp.**	399	1.91	-	-	0.0
Crinoid debris	1504#				100.0
Echinoid debris	517#				100.0
Holothurian debris	896#				100.0
Ophiuroid and/or Asteroid debris	1393#				100.0
Scolecodonts	256#				
Faecal pellets	6752#				

LOCALITY C-803.7'   HORIZON III

Taxonomic Entity	Total No. of Indiv.	Percent of Indiv.	Percent Artic.	Percent BV or LV	Percent Broken
Ammobaculites sp.	256	0.41	-	-	-
Ammodiscus sp.	5280	8.56	-	-	-
Bathysiphon sp.	1152	1.87	-	-	-
Earlandinita sp.	192	0.31	-	-	-
Endothyra sp.	768	1.24	-	-	-
Endothyranella sp.	2112	3.42	-	-	-
Reophax sp.	4032	6.54	-	-	-
Tolypammina sp.	112	0.18	-	-	-
Sponge spicules	144#				
Lingula cf. L. carbonaria	448	0.73	100.0		100.0
Lindstroemella cf. L. patula**	16	0.026	100.0		37.5
Crurithyris planoconvexa**	704	1.14	83.3	0.0	25.0
Mesolobus decipiens	2	0.0032	*	*	*
Plagioglypta sp.**	784	1.27	-	-	100.0
Allorisma sp.	2	0.0032	*	*	*
Anthraconeilo taffiana**	7922	12.84	98.8	100.0	25.0
Astartella cf. A. concentrica	32	0.052	0.0	100.0	0.0
Nuculopsis (Palaeonucula) anodontoides**	6135	9.95	96.8	50.0	95.6
Nuculopsis (Palaeonucula) wewokana**	6424	10.41	92.0	40.0	11.1
Nuculopsis girtyi**	17	0.027	88.2	50.0	0.0
Paleyoldia glabra**	19	0.031	100.0		100.0
Polidevica bellistriata**	860	1.39	87.8	20.0	14.3
Schizodus sp.	832	1.35	38.5	37.5	0.0
Euphemites carbonarius**	2194	8.42	-	-	100.0
Girtyspira sp.	160	0.26	-	-	0.0
Glabrocingulum (A.) grayvillensis**	11,202	18.16	-	-	23.6
Ianthinopsis sp.**	769	1.25	-	-	0.0
Meekospira peracuta**	1691	2.74	-	-	100.0
Phymatopleura nodosus	2	0.0032	-	-	*

LOCALITY C-803.7' HORIZON III--(Concluded)

Taxonomic Entity	Total No. of Indiv.	Percent of Indiv.	Percent Artic.	Percent BV or LV	Percent Broken
Pseudozygopleurids**	1504	2.44	-	-	0.0
*Trepospira depressa***	4058	6.58	-	-	33.6
Pseudorthoceras sp.	3	0.0049	-	-	*
Gastrioceras sp.**	115	0.19	-	-	33.3
Metacoceras sp.	1	0.0016	-	-	*
Amphissites sp.	448	0.73	100.0		0.0
Bairdia sp.	704	1.14	100.0		0.0
Healdia sp.	672	1.09	100.0		0.0
Moorites sp.	32	0.052	100.0		0.0
Other ostracodes	32	0.052	100.0		0.0
Crinoid debris	10,963#				100.0
Echinoid debris	2517#				100.0
Holothurian debris	1920#				100.0
Ophiuroid and/or Asteroid debris	8880#				100.0
Hindeodellids	384#				
Idiognathodus sp.	32#				
Ozarkodina sp.	128#				
Fish debris	65#				
Faecal pellets	11,445#				

LOCALITY E-800.5' HORIZON III

Taxonomic Entity	Total No. of Indiv.	Percent of Indiv.	Percent Artic.	Percent BV or LV	Percent Broken
Ammobaculites sp.	2624	4.92	-	-	-
Ammodiscus sp.	3840	7.21	-	-	-
Bathysiphon sp.	512	0.96	-	-	-
Earlandinita sp.	1792	3.36	-	-	-
Endothyranella sp.	3328	6.24	-	-	-
Lituotuba sp.	1280	2.40	-	-	-
Reophax sp.	6144	11.53	-	-	-
Lophophyllum sp.	1	0.0019	-	-	*
Lingula cf. L. carbonaria**	1600	3.00	100.0		0.0?
Lindstroemella cf. L. patula	4	0.0075	*	*	*
Crurithyris planoconvexa**	2613	4.90	84.4	0.0	47.6
Mesolobus decipiens**	68	0.13	100.0		50.0
Plagioglypta sp.**	2275	4.27	-	-	100.0
Anthraconeilo taffiana**	2991	5.61	100.0		33.3
Nuculopsis (Palaeonucula) anodontoides**	1347	2.53	100.0		0.0
Nuculopsis (Palaeonucula) wewokana**	3302	6.20	95.4	100.0	0.0
Nuculopsis girtyi	3	0.0056	*	*	*
Paleyoldia glabra	2	0.0037	*	*	*
Polidevica bellistriata**	598	1.12	92.9		59.1
Euphemites carbonarius**	1541	2.89	-	-	20.0
Girtyspira sp.	64	0.12	-	-	0.0
Glabrocingulum (A.) grayvillensis**	5749	10.79	-	-	48.6
Ianthinopsis sp.**	1152	2.16	-	-	0.0
Knightites (Cymatospira) sp.	1	0.0019	-	-	*
Meekospira peracuta**	748	1.40	-	-	100.0
Phymatopleura nodosus	5	0.0094	-	-	*
Pseudozygopleurids**	928	1.74	-	-	0.0
Trepospira depressa**	4231	7.94	-	-	61.9

LOCALITY E-800.5'--(Concluded) HORIZON III

Taxonomic Entity	Total No. of Indiv.	Percent of Indiv.	Percent Artic.	Percent BV or LV	Percent Broken
Pseudorthoceras sp.**	264	0.49	-	-	100.0
Gastrioceras sp.**	1403	2.63	-	-	29.6
Ditomoypge cf. D. parvulus	1	0.0019	-	-	*
Amphissites sp.	256	0.48	100.0		0.0
Bairdia sp.	1856	3.48	100.0		0.0
Healdia sp.	768	1.44	100.0		0.0
Crinoid debris	3989#				100.0
Echinoid debris	1517#				100.0
Holothurian debris	3136#				100.0
Ophiuroid and/or Asteroid debris	5664#				100.0
Scolecodonts	256#				
Fish debris	256#				
Faecal pellets	5120#				

LOCALITY F-789.9' HORIZON III

Taxonomic Entity	Total No. of Indiv.	Percent of Indiv.	Percent Artic.	Percent BV or LV	Percent Broken
Ammobaculites sp.	1920	6.85	-	-	-
Ammodiscus sp.	1280	4.57	-	-	-
Bathysiphon sp.	768	2.74	-	-	-
Earlandinita sp.	512	1.83	-	-	-
Endothyranella sp.	512	1.83	-	-	-
Lituotuba sp.	1024	3.65	-	-	-
Reophax sp.	3072	10.96	-	-	-
Sponge spicules	32#		-	-	-
Lophophyllum sp.	1	0.0036	-	-	*
Lindstroemella cf. L. patula	4	0.014	*	*	*
Crurithyris planoconvexa**	271	0.97	70.6	20.2	40.0
Mesolobus decipiens	4	0.014	*	*	*
Plagioglypta sp.**	896	3.19	-	-	100.0
Allorisma sp.	3	0.011	*	*	*
Anthraconeilo taffiana**	2047	7.30	98.6	100.0	41.3
Astartella cf. A. concentrica	4	0.014	*	*	*
Aviculopecten sp.	1	0.0036	*	*	*
Nuculopsis (Palaeonucula) anodontoides**	32	0.11	100.0		0.0
Nuculopsis (Palaeonucula) wewokana**	3081	10.99	95.6	0.0	0.0
Nuculopsis girtyi**	40	0.14	77.8	100.0	12.5
Paleyoldia glabra**	1669	5.95	91.7	0.0	80.0
Polidevica bellistriata**	1073	3.83	81.8	50.0	52.9
Euphemites carbonarius**	1861	6.64	-	-	0.0
Glabrocingulum (A.) grayvillensis**	3806	13.57	-	-	44.9
Ianthinopsis sp.**	514	1.83	-	-	0.0

LOCALITY F-789.9'--(Concluded   HORIZON III

Taxonomic Entity	Total No. of Indiv.	Percent of Indiv.	Percent Artic.	Percent BV or LV	Percent Broken
Knightites (Cymatospira) sp.	1	0.0036	-	-	*
Meekospira peracuta**	556	1.98	-	-	100.0
Pseudozygopleurids	768	2.74	-	-	0.0
Trepospira depressa**	2186	7.80	-	-	58.1
Pseudorthoceras sp.	1	0.0036	-	-	*
Gastrioceras sp.**	130	0.46	-	-	50.0
Crinoid debris	7968#				100.0
Echinoid debris	864#				100.0
Holothurian debris	1024#				100.0
Ophiuroid and/or Asteroid debris	13,920#				100.0
Unidentifiable conodonts	256#				
Fish debris	128#				
Faecal pellets	25,728#				

LOCALITY F-791.2' HORIZON III

Taxonomic Entity	Total No. of Indiv.	Percent of Indiv.	Percent Artic.	Percent BV or LV	Percent Broken
Ammobaculites sp.	5504	13.06	-	-	-
Ammodiscus sp.	9792	23.24	-	-	-
Endothyranella sp.	2048	4.86	-	-	-
Lituotuba sp.	896	2.13	-	-	-
Reophax sp.	2624	6.23	-	-	-
Tolypammina sp.	96	0.23	-	-	-
Lindstroemella cf. L. patula	2	0.0047	*	*	*
Crurithyris planoconvexa**	2701	6.41	75.9	14.3	61.5
Plagioglypta sp.**	1374	3.26	-	-	100.0
Anthraconeilo taffiana**	1598	3.79	100.0		40.0
Astartella cf. A.concentrica**	68	0.16	40.0	0.0	100.0
Nuculopsis (Palaeonucula) anodontoides**	1253	2.97	100.0		0.0
Nuculopsis (Palaeonucula) wewokana**	3083	7.32	90.6	66.7	0.0
Nuculopsis girtyi	5	0.012	*	*	*
Paleyoldia glabra	7	0.017	*	*	*
Polidevica bellistriata**	92	0.22	72.4	100.0	67.8
Bellerophon (B.) cf. B. (B.) crassus	2	0.0047	-	-	*
Euphemites carbonarius**	546	1.30	-	-	0.0
Girtyspira sp.	160	0.38	-	-	0.0
Glabrocingulum (A.) gray-villensis**	3395	8.06	-	-	48.5
Ianthinopsis sp.**	384	0.91	-	-	0.0
Knightites (Cymatospira) cf. K. (C.) montfortianum	1	0.0024	-	-	*
Meekospira peracuta**	972	2.31	-	-	91.7
Pseudozygopleurids**	576	1.37	-	-	0.0
Trepospira depressa**	1514	3.59	-	-	45.2
Pseudorthoceras sp.	6	0.014	-	-	*
Gastriceras sp.**	1253	2.97	-	-	60.0
Bairdia sp.	2176	5.17	100.0		0.0

LOCALITY F-791.2'--(Concluded) HORIZON III

Taxonomic Entity	Total No. of Indiv.	Percent of Indiv.	Percent Artic.	Percent BV or LV	Percent Broken
Crinoid debris	2467#				100.0
Echinoid debris	3525#				100.0
Holothurian debris	1664#				100.0
Ophiuroid and/or Asteroid debris	20,864#				100.0
Unidentifiable conodonts	64#				
Fish debris	64#				
Faecal pellets	3488#				

LOCALITY E-826.0' HORIZON IV

Taxonomic Entity	Total No. of Indiv.	Percent of Indiv.	Percent Artic.	Percent BV or LV	Percent Broken
Ammobaculites sp.	24,576	23.65	-	-	-
Ammodiscus sp.	1152	1.11	-	-	-
Bathysiphon sp.	768	0.74	-	-	-
Earlandinita sp.	5632	5.42	-	-	-
Endothyranella sp.	10,272	9.89	-	-	-
Globovalvulina sp.	128	0.12	-	-	-
Lituotuba sp.	1408	1.35	-	-	-
Tolypammina sp.	5808	5.59	-	-	-
Lophophyllum cf. L. profundum	12	0.011	-	-	100.0
?Acanthocladia sp.	1	0.0009	-	-	*
Fenestrate Bryozoa	1	0.0009	-	-	*
Ramose Bryozoa	1044	1.00	-	-	100.0
Lindstroemella cf. L. patula	258	0.25	100.0		50.0
Cleiothyridina orbicularis	4	0.0038	*	*	*
Crurithyris planoconvexa**	3045	2.93	25.9	16.9	80.5
Derbyia cf. D. crassa	1	0.0009	*	*	*
Hustedia cf. H. mormoni	7	0.0067	*	*	*
Marginiferid fragments	1	0.0009	*	*	*
Mesolobus euampygus**	1282	1.23	34.3	88.5	44.4
Neospirifer sp.	1	0.009	*	*	*
Other Productoid fragments	832#				
Plagioglypta sp.**	817	0.79	-	-	100.0
Allorisma sp.	2	0.0019	*	*	*
Anthraconeilo taffiana	13	0.013	84.6	50.0	30.8
Astartella cf. A. concentrica**	124	0.12	10.7	56.3	78.6
Nuculopsis (Palaeonucula) anodontoides**	101	0.097	100.0		20.0
Nuculopsis (Palaeonucula) wewokana**	701	0.67	85.3	40.0	20.7
Paleyoldia glabra	2	0.0019	*	*	*

LOCALITY E-826.0'--(Continued) HORIZON IV

Taxonomic Entity	Total No. of Indiv.	Percent of Indiv.	Percent Artic.	Percent BV or LV	Percent Broken
Polidevica bellistriata**	48	0.046	62.5	50.0	43.7
Straparolus (Amphiscapha) catilloides**	69	0.066	-	-	40.0
Bellerophon (B.) cf. B. (B.) crassus**	582	0.56	-	-	16.7
Euphemites carbonarius**	871	0.84	-	-	42.8
Glabrocingulum (A.) grayvillensis**	2938	2.83	-	-	57.7
Ianthinopsis sp.**	1650	1.59	-	-	16.7
Knightites (Cymatospira) montfortianum**	37	0.036	-	-	60.0
Meekospira peracuta**	3557	3.42	-	-	76.0
Pseudozygopleurids**	6727	6.47	-	-	0.0
Trepospira depressa**	3148	3.03	-	-	50.0
Pseudorthoceras sp.**	32	0.031	-	-	100.0
Gastrioceras sp.	325	0.31	-	-	100.0
Trilobites fragments	1652#				100.0
Amphissites sp.	4224	4.07	63.6	?	0.0
Bairdia sp.	12,544	12.07	73.5	?	0.0
Cavellina sp.	2048	1.97	100.0		0.0
Healdia sp.	6912	6.65	100.0		0.0
Hollinella sp.	512	0.49	100.0		0.0
Moorites sp.	512	0.49	100.0		0.0
Crinoid debris	24,851#				100.0
Echinoid debris	2510#				100.0
Holothurian debris	7808#				100.0
Ophiuroid and/or Asteroid debris	1152#				100.0
Hindeodellids	1536#				
Idiognathodus sp.	128#				

LOCALITY E-826.0'--(Concluded) HORIZON IV

Taxonomic Entity	Total No. of Indiv.	Percent of Indiv.	Percent	Percent BV or LV	Percent Broken
Fish debris	128#				
Faecal pellets	6324#				
Plant fragments	5#				

LOCALITY E-827.2' HORIZON IV

Taxonomic Entity	Total No. of Indiv.	Percent of Indiv.	Percent Artic.	Percent BV or LV	Percent Broken
Ammobaculites sp.	34,112	34.42	-	-	-
Ammodiscus sp.	8192	8.75	-	-	-
Bathysiphon sp.	5760	6.15	-	-	-
Earlandinita sp.	6656	7.11	-	-	-
Endothyranella sp.	2624	2.80	-	-	-
Globovalvulina sp.	512	0.55	-	-	-
Lituotuba sp.	320	0.34	-	-	-
Reophax sp.	2560	2.73	-	-	-
Tolypammina sp.	2064	2.20	-	-	-
Ramose Bryozoa	1866	1.99	-	-	100.0
Cleiothyridina orbicularis	1	0.0011	*	*	*
Cruritbyris planoconvexa**	1237	1.32	74.6	6.7	49.1
Mesolobus euampygus**	217	0.23	79.3	100.0	24.0
Productoid fragments	1664#				
Plagioglypta sp.**	518	0.55	-	-	100.0
Anthraconeilo taffiana**	692	0.74	95.8	0.0	45.0
Astartella cf. A. concentrica**	141	0.15	40.0	66.7	76.9
Nuculopsis (Palaeonucula) anodontoides**	680	0.73	100.0		12.5
Nuculopsis (Palaeonucula) wewokana**	3314	3.54	89.7	0.0	0.0
Nuculopsis girtyi**	75	0.08	60.0	50.0	63.6
Paleyoldia glabra	2	0.0021	*	*	*
Polidevica bellistriata**	166	0.18	87.2	40.0	71.1
Straparolus (Amphiscapha) catilloides**	131	0.14	-	-	66.7
Bellerophon (B.) cf. B. (B.) crassus**	1671	1.78	-	-	28.6
Euphemites carbonarius**	521	0.56	-	-	0.0
Glabrocingulum (A.) grayvillensis**	1820	1.94	-	-	64.5
Ianthinopsis sp.**	1926	2.06	-	-	0.0

LOCALITY E-827.2'--(Concluded) HORIZON IV

Taxonomic Entity	Total No.of Indiv.	Percent of Indiv.	Percent Artic.	Percent BV or LV	Percent Broken
Knightites (Cymatospira) montfortianum**	66	0.07	-	-	100.0
Meekospira peracuta**	1897	2.02	-	-	100.0
Bellerophon (Pharkidonotus) pericarinatus	1	0.0011	-	-	*
Phymatopleura nodosus	131	0.14	-	-	33.3
Pseudozygopleurids**	323	0.34	-	-	0.0
Trepospira depressa**	2553	2.73	-	-	73.0
Pseudorthoceras sp.**	12	0.013	-	-	100.0
Gastrioceras sp.**	271	0.29	-	-	66.7
Trilobite fragments	40#				100.0
Amphissites sp.	64	0.068	100.0		0.0
Bairdia sp.	10,496	11.21	100.0		0.0
Hollinella sp.	64	0.068	100.0		0.0
Crinoid debris	16,869#				100.0
Echinoid debris	4548#				100.0
Holothurian debris	1536#				100.0
Ophiuroid and/or Asteroid debris	1568#				100.0
Idiognathodus sp.	512#				
Fish debris	4160#				
Faecal pellets	11,880#				
Plant fragments	1#				

LOCALITY G-816.0' HORIZON IV

Taxonomic Entity	Total No. of Indiv.	Percent of Indiv.	Percent Artic.	Percent BV or LV	Percent Broken
Ammobaculites sp.	17,792	37.83	-	-	-
Ammodiscus sp.	7936	16.87	-	-	-
Bathysiphon sp.	640	1.36	-	-	-
Earlandinita sp.	128	0.27	-	-	-
Endothyranella sp.	1920	4.08	-	-	-
Globovalvulina sp.	128	0.27	-	-	-
Lituotuba sp.	240	0.51	-	-	-
Reophax sp.	768	1.63	-	-	-
Tolypammina sp.	2	0.0043	-	-	-
Fistuliporids	1	0.0021	-	-	*
Ramose Bryozoa	188	0.40	-	-	100.0
Lingula cf. L. carbonaria	1	0.0021	*	*	*
Lindstroemella cf. L. patula	3	0.0064	*	*	*
Cleiothyridina orbicularis**	1311	2.79	53.6	76.9	60.0
Composita cf. C. subtilita	1	0.0021	*	*	*
Cruritiyris planoconvexa**	94	0.20	43.7	55.5	50.0
Derbyia sp. fragment	1	0.0021	*	*	*
Hustedia cf. H. mormoni	1	0.0021	*	*	*
Mesolobus decipiens**	594	1.26	42.1	32.7	42.7
Mesolobus euampygus**	342	0.73	26.7	54.5	46.3
Rhipidomella sp.	1	0.0021	*	*	*
Productoid fragments	1421#				
Plagioglypta sp.**	630	1.34	-	-	100.0
Anthraconeilo taffiana	3	0.0064	*	*	*
Nuculopsis (Palaeonucula) wewokana**	1108	2.36	100.0		0.0
Bellerophon (B.) cf. B. (B.) crassus	1	0.0021	-	-	*
Euphemites carbonarius**	641	1.36	-	-	0.0
Girtyspira sp.	192	0.41	-	-	0.0
Glabrocingulum (A.) grayvillensis**	589	1.25	-	-	51.7
Ianthinopsis sp.**	211	0.45	-	-	0.0

LOCALITY G-816.0'--(Concluded) HORIZON IV

Taxonomic Entity	Total No. of Indiv.	Percent of Indiv.	Percent Artic.	Percent BV or LV	Percent Broken
Meekospira peracuta**	421	0.89	-	-	100.0
Phymatopleura nodosus	1	0.0021	-	-	*
Pseudozygopleurids**	3459	7.35	-	-	0.0
Soleniscus sp.**	114	0.24	-	-	50.0
Trepospira depressa	384	0.82	-	-	100.0
Pseudorthoceras sp.**	46	0.098	-	-	100.0
Trilobites fragments	216#				100.0
Amphissites sp.	768	1.63	50.0	?	0.0
Bairdia sp.	4176	8.88	49.4	?	0.0
Healdia sp.	1424	3.03	100.0		0.0
Hollinella sp.	640	1.36	100.0		0.0
Moorites sp.	128	0.27	100.0	-	0.0
Crinoid debris	9019#				100.0
Echinoid debris	1394#				100.0
Holothurian debris	624#				100.0
Ophiuroid and/or Asteroid debris	865#				100.0
Hindeodellids	256#				
Streptognathodus sp.	256#				

LOCALITY G-815.1' HORIZON IV

Taxonomic Entity	Total No. of Indiv.	Percent of Indiv.	Percent Artic.	Percent BV or LV	Percent Broken
Ammobaculites sp.	10,912	26.86	-	-	-
Ammodiscus sp.	8096	19.93	-	-	-
Bathysiphon sp.	1344	3.31	-	-	-
Earlandinita sp.	256	0.63	-	-	-
Endothyranella sp.	384	0.95	-	-	-
Lituotuba sp.	672	1.65	-	-	-
Reophax sp.	896	2.21	-	-	-
Tolypammina sp.	206	0.51	-	-	-
Fistuliporids	3	0.0074	-	-	*
Ramose Bryozoa	233	0.57	-	-	100.0
Lingula cf. L. carbonaria	1	0.0025	*	*	*
Lindstroemella cf. L. patula	8	0.020	*	*	*
Cleiothyridina orbicularis**	750	1.85	81.8	50.0	78.6
Crurithyris planoconvexa**	662	1.63	66.7	83.3	34.8
Derbyia sp. fragments	2#				
Mesolobus decipiens**	595	1.46	57.4	53.1	72.2
Mesolobus euampygus**	133	0.33	50.0	76.9	28.6
Productoid fragments	1155#				
Plagioglypta sp.**	275	0.68	-	-	100.0
Anthraconeilo taffiana**	195	0.48	100.0		33.3
Nuculopsis (Palaeonucula) anodontoides	16	0.039	100.0		0.0
Nuculopsis (Palaeonucula) wewokana**	394	0.97	100.0		20.0
Nuculopsis girtyi	1	0.0025	*	*	*
Paleyoldia glabra	1	0.0025	*	*	*
Euphemites carbonarius**	65	0.16	-	-	100.0
Glabrocingulum (A.) grayvillensis**	403	0.99	-	-	89.5
Ianthinopsis sp.**	418	1.03	-	-	0.0
Meekospira peracuta**	224	0.55	-	-	100.0
Pseudozygopleurids**	2436	6.00	-	-	25.0

LOCALITY G-815.1'--(Concluded) HORIZON IV

Taxonomic Entity	Total No. of Indiv.	Percent of Indiv.	Percent Artic.	Percent BV or LV	Percent Broken
Trepospira depressa**	355	0.87	-	-	100.0
Pseudorthoceras sp.	3	0.0074	-	-	*
Gastrioceras sp.**	224	0.55	-	-	0.0
Trilobite fragments	130#				100.0
Amphissites sp.	256	0.63	0.0	?	100.0
Bairdia sp.	7520	18.51	100.0		0.0
Healdia sp.	2432	5.99	100.0		0.0
Hollinella sp.	128	0.31	50.0	?	0.0
Moorites sp.	128	0.31	100.0		0.0
Crinoid debris	15,001#				100.0
Echinoid debris	1536#				100.0
Holothurian debris	640#				100.0
Ophiuroid and/or Asteroid debris	608#				100.0
Idiognathodus sp.	32#				
Other Conodonts	128#				
Faecal pellets	768#				

LOCALITY E-835.0'   HORIZON V

Taxonomic Entity	Total No. of Indiv.	Percent of Indiv.	Percent Artic.	Percent BV or LV	Percent Broken
Ammodiscus sp.	15,744	48.22	-	-	-
Bathysiphon sp.	1792	5.49	-	-	-
Earlandinita sp.	4736	14.51	-	-	-
Fusulina sp.	640	1.96	-	-	-
Lituotuba sp.	1296	3.97	-	-	-
Reophax sp.	640	1.96	-	-	-
Tolypammina sp.	384	1.18	-	-	-
Fistuliporids	12	0.037	-	-	100.0
Ramose Bryozoa	32	0.098	-	-	100.0
Lindstroemella cf. L. patula	88	0.27	100.0?		62.5
Chonetinella cf. C. flemingi	1	0.0031	*	*	*
Cleiothyridina orbicularis**	83	0.25	100.0		33.3
Crurithyris planoconvexa**	397	1.21	76.2	0.0	46.1
Mesolobus euampygus**	73	0.22	53.9	83.3	44.0
Plagioglypta sp.**	128	0.39	-	-	100.0
Anthraconeilo taffiana	2	0.0061	*	*	*
Nuculopsis (Palaeonucula) anodontoides**	192	0.59	100.0		0.0
Nuculopsis (Palaeonucula) wewokana**	320	0.98	100.0		0.0
Straparolus (Amphiscapha) catilloides	128	0.39	-	-	0.0
Euphemites carbonarius	1	0.0031	-	-	*
Glabrocingulum (A.) grayvillensis**	341	1.04	-	-	0.0
Ianthinopsis sp.**	448	1.37	-	-	0.0
Meekospira peractua**	49	0.15	-	-	100.0
Pseudozygopleurids**	1344	4.12	-	-	0.0
Trepospira depressa**	642	1.97	-	-	0.0
Pseudorthoceras sp.	1	0.0031	-	-	*

LOCALITY E-835.0'--(Concluded) HORIZON V

Taxonomic Entity	Total No. of Indiv.	Percent of Indiv.	Percent Artic.	Percent BV or LV	Percent Broken
Ditomopyge sp. fragments	149#				100.0
Amphissites sp.	256	0.78	100.0		0.0
Bairdia sp.	1472	4.51	100.0		0.0
Cavellina sp.	896	2.74	100.0		0.0
Healdia sp.	256	0.78	100.0		0.0
Hollinella sp.	256	0.78	100.0		0.0
Crinoid debris	6670#				100.0
Echinoid debris	1505#				100.0
Holothurian debris	384#				100.0
Ophiuroid and/or Asteroid debris	272#				100.0
Gnathodus sp.	128#				
Hindeodillids	256#				
Idiognathodus sp.	256#				
Streptognathodus sp.	384#				
Other Conodonts	128#				
Fish debris	256#				

LOCALITY E-835.5'　　　HORIZON V

Taxonomic Entity	Total No. of Indiv.	Percent of Indiv.	Percent Artic.	Percent BV or LV	Percent Broken
Ammobaculites sp.	9600	18.19	-	-	-
Ammodiscus sp.	8192	15.52	-	-	-
Bathysiphon sp.	384	0.73	-	-	-
Earlandinita sp.	256	0.49	-	-	-
Endothyranella sp.	1152	2.18	-	-	-
Fusulina sp.	65	0.12	-	-	-
Lituotuba sp.	2080	3.94	-	-	-
Reophax sp.	512	0.97	-	-	-
Tolypammina sp.	979	1.85	-	-	-
Lophophyllum cf. L. profundum	3	0.0057	-	-	*
Fenestrate Bryozoa	512	0.97	-	-	100.0
Fistuliporids	6	0.011	-	-	*
Prismopora sp.	2	0.0038	-	-	*
Ramose Bryozoa	466	0.88	-	-	100.0
Lingula cf. L. carbonaria	128	0.24	?	?	100.0
Lindstroemella cf. L. patula	2	0.0038	*	*	*
Cancrinella sp.	1	0.0019	*	*	*
Chonetinella cf. C. flemingi	3	0.0057	*	*	*
Cleiothyridina orbicularis**	2327	4.41	64.7	73.6	57.6
Crurithyris planoconvexa**	1397	2.65	35.3	18.7	74.1
Derbyia cf. D. crassa	7	0.013	*	*	*
Derbyia sp.	1	0.0019	*	*	*
Hustedia cf. H. mormoni	2	0.0038	*	*	*
Marginiferid fragments	1	0.0019	*	*	*
Mesolobus euampygus**	383	0.73	44.9	60.5	31.7
Other Productoid fragments	832#				
Plagioglypta sp.**	652	1.24	-	-	100.0
Anthraconeilo taffiana**	134	0.25	85.7	100.0	66.7
Nuculopsis (Palaeonucula) wewokana**	294	0.56	100.0		66.7

LOCALITY E-835.5'-- (Concluded) HORIZON V

Taxonomic Entity	Total No. of Indiv.	Percent of Indiv.	Percent Artic.	Percent BV or LV	Percent Broken
Polidevica bellistriata**	259	0.49	85.7	100.0	66.7
Straparolus (Amphiscapha) catilloides**	320	0.61	-	-	0.0
Bellerophon (B.) cf. B. (B.) crassus	64	0.12	-	-	0.0
Euphemites carbonarius**	613	1.16	-	-	40.0
Girtyspira sp.	128	0.24	-	-	0.0
Glabrocingulum (A.) grayvillensis**	1138	2.16	-	-	82.0
Ianthinopsis sp.**	739	1.40	-	-	0.0
Knightites (Cymatospira) cf. K. (C.) montfortianum	1	0.0019	-	-	*
Meekospira peracuta**	1186	2.25	-	-	50.0
Phymatopleura nodosus	3	0.0057	-	-	*
Pseudozygopleurids**	7653	14.50	-	-	60.0
Soleniscus sp.**	196	0.37	-	-	50.0
Trepospira depressa**	1920	3.64	-	-	100.0
Pseudorthoceras sp.**	43	0.081	-	-	50.0
Gastrioceras sp.	256	0.49	-	-	50.0
Ditomopyge cf. D. parvulus	1	0.0019	-	-	*
Trilobites fragments	1648#				100.0
Bairdia sp.	5568#	10.55	86.3	?	0.0
Healdia sp.	2304	4.37	100.0		0.0
Hollinella sp.	704	1.33	72.7	?	0.0
Moorites sp.	128	0.24	100.0		0.0
Crinoid debris	15,508#				100.0
Echinoid debris	4267#				100.0
Holothurian debris	2048#				100.0
Ophiuroid and/or Asteroid debris	5700#				100.0
Hindeodellids	256#				
Idiognathodus sp.	128#				
Other Conodonts	192#				
Faecal pellets	4192#				

LOCALITY G-824.0' HORIZON V

Taxonomic Entity	Total No. of Indiv.	Percent of Indiv.	Percent Artic.	Percent BV or LV	Percent Broken
Ammobaculites sp.	5696	29.48	-	-	-
Ammodiscus sp.	2176	11.25	-	-	-
Bathysiphon sp.	7424	38.42	-	-	-
Earlandinita sp.	1280	6.62	-	-	-
Reophax sp.	1376	7.12	-	-	-
Lindstroemella cf. L. patula	10	0.052	100.0		60.0
Mesolobus decipiens**	732	3.79	69.3	50.7	86.5
Productoid fragments	3728#				
Strophalosids	3	0.015	*	*	*
Euphemites carbonarius	32	0.17	-	-	0.0
Pseudozygopleurids	64	0.33	-	-	0.0
Pseudorthoceras sp.	16	0.083	-	-	100.0
Bairdia sp.	512	2.65	100.0		0.0
Crinoid debris	1728#				100.0
Echinoid debris	320#				100.0
Holothurian debris	320#				100.0
Ophiuroid and/or Asteroid debris	64#				100.0

LOCALITY G-825.0'   HORIZON V

Taxonomic Entity	Total No. of Indiv.	Percent of Indiv.	Percent Artic.	Percent BV or LV	Percent Broken
Ammobaculites sp.	15,936	48.47	-	-	-
Ammodiscus sp.	3840	11.68	-	-	-
Bathysiphon sp.	5760	17.52	-	-	-
Earlandinita sp.	1792	5.45	-	-	-
Lituotuba sp.	640	1.95	-	-	-
Reophax sp.	1152	3.50	-	-	-
Tolypammina sp.	45	0.14	-	-	-
Lingula cf. *L. carbonaria*	128	0.39	100.0?		0.0
Lindstroemella cf. *L. patula*	2	0.0061	*	*	*
Cleiothyridina orbicularis	16	0.049	?	?	100.0
Crurithyris planoconvexa	100	0.30	20.0	60.0	100.0
*Mesolobus decipiens***	87	0.26	71.4	41.7	74.4
*Mesolobus euampygus***	129	0.39	57.1	42.9	55.7
Productoid fragments	2772#				
Plagioglypta sp.	32	0.097	-	-	100.0
Nuculopsis (*Palaeonucula*) *wewokana*	1	0.003	*	*	*
Euphemites carbonarius	32	0.097	-	-	0.0
Pseudozygopleurids	128	0.39	-	-	0.0
Pseudorthoceras sp.	16	0.049	-	-	100.0
Bairdia sp.	2656	8.08	100.0		0.0
Healdia sp.	384	1.17	100.0		0.0
Crinoid debris	10,892#				100.0
Echinoid debris	2080#				100.0
Ophiuroid and/or Asteroid debris	1397#				100.0

APPENDIX IV

SOME REPRESENTATIVE FOSSILS FROM THE WEWOKAN MARINE COMMUNITIES

PLATE IV

Fig. 1. Lindstroemella cf. L. patula; (Glabrocingulum Community); X1; pedicle valve exterior.

Fig. 2. Lingula cf. L. carbonaria; (Glabrocingulum Community); X2; pedicle valve exterior.

Fig. 3. Lindstroemella cf. L. patula attached to the brachial valve of Mesolobus decipiens; (Mesolobus Community); X2.

Fig. 4. Mesolobus decipiens; (Cleiothyridina Community); X2; pedicle valve exterior.

Fig. 5. Mesolobus euampygus; (Cleiothyridina Community); X3; pedicle valve exterior.

Fig. 6. Crurithyris planoconvexa; (Glabrocingulum Community); X2; brachial valve exterior.

Fig. 7. Cleiothyridina orbicularis; (Cleiothyridina Community); X1; pedicle valve exterior.

Fig. 8. Nuculopsis (P.) anodontoides; (Transitional Community); X1; on bedding plane of claystone.

Fig. 9. Nuculopsis (P.) wewokana; (Transitional Community); X3; right valve exterior.

Fig. 10. Hustedia cf. H. mormoni; (transported element in Cleiothyridina Community); X2; brachial valve exterior.

Fig. 11. Paleyoldia glabra; (Glabrocingulum Community); X1; left valve exterior.

Fig. 12. Pseudozygopleurid snail; (Cleiothyridina Community); X2; adaperatural view.

Fig. 13. Anthraconeilo taffiana; (Glabrocingulum Community); X1; right valve exterior.

Fig. 14. Shark tooth; (Transitional Community); X1.

PLATE IV--(Continued)

Fig. 15. Trepospira depressa; (Glabrocingulum Community); X1; apical view.

Fig. 16. Astartella cf. A. concentrica; (Transitional Community); X2; right valve exterior.

Fig. 17. Euphemites carbonarius; (Glabrocingulum Community); X1; aperatural view.

Fig. 18. Ianthinopsis sp.; (Glabrocingulum Community); X1; aperatural view.

Fig. 19. Straparolus (A.) catilloides; (Cleiothyridina Community); X2; apical view.

Fig. 20. Polidevica bellistriata; (Glabrocingulum Community); X1; left valve exterior; in "life position," arrow points up.

Fig. 21. Gastrioceras sp.; (Glabrocingulum Community); X1; lateral view.

Fig. 22. Ditymopyge cf. D. parvulus; (Cleiothyridina Community); X2; dorsal exterior.

Fig. 23. Pseudorthoceras sp.; (Cleiothyridina Community); X1.

Fig. 24. Glabrocingulum (A.) grayvillensis; (Glabrocingulum Community); X2; adaperatural view.

Fig. 25. Conularia cf. C. crustula; (Glabrocingulum Community); X2.

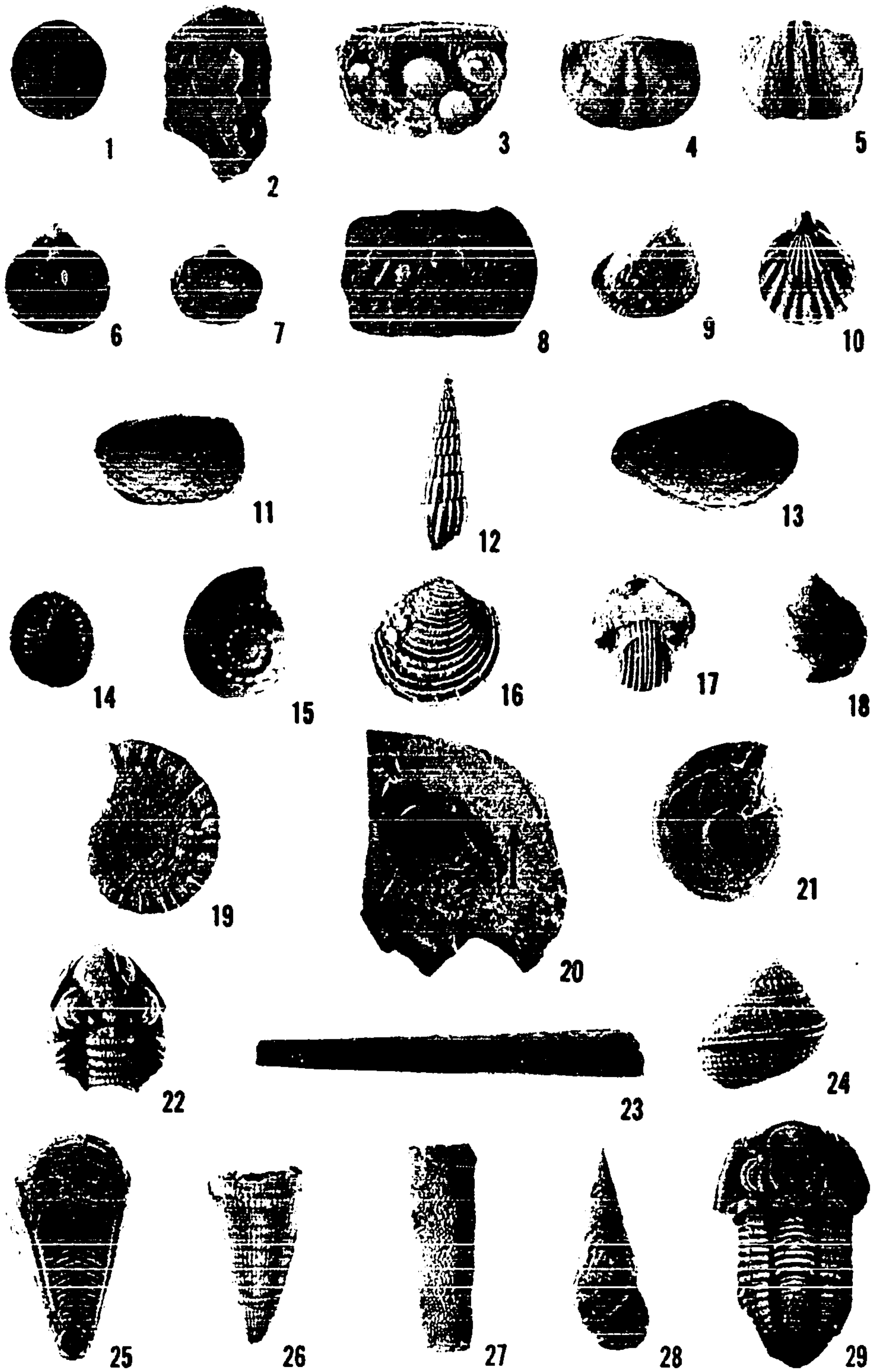
Fig. 26. Lophophyllum cf. L. profundum; (Transitional Community); X1.

Fig. 27. Fistuliporid bryozoan encrusting crinoid columnal; (Cleiothyridina Community); X1.

Fig. 28. Meekospira percuta; (Glabrocingulum Community); X1; aperatural view.

Fig. 29. Ameura sangamonensis; (Cleiothyridina Community); X1; dorsal exterior.

PLATE IV

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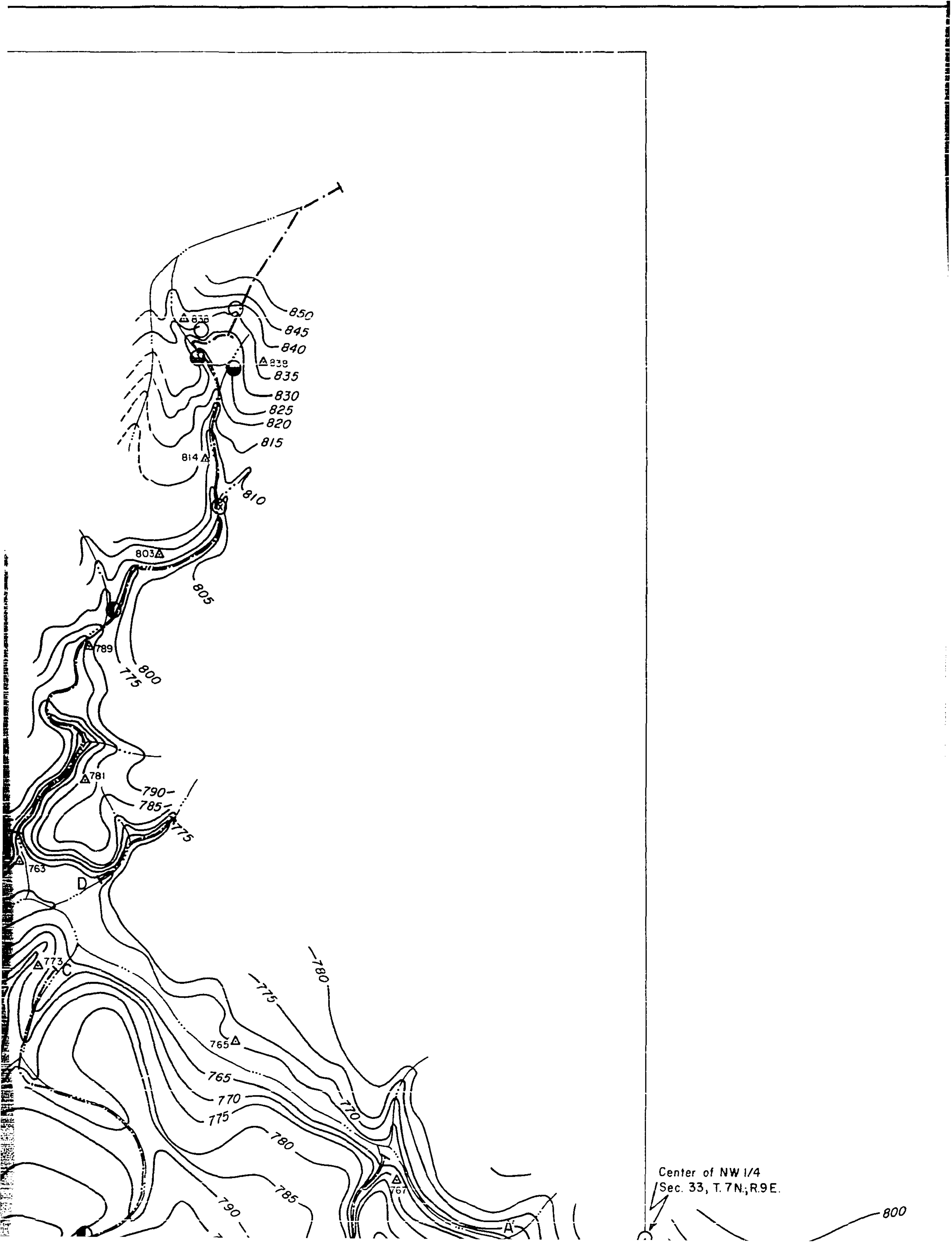
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Center of NW 1/4
Sec. 33, T. 7N.; R.9E.
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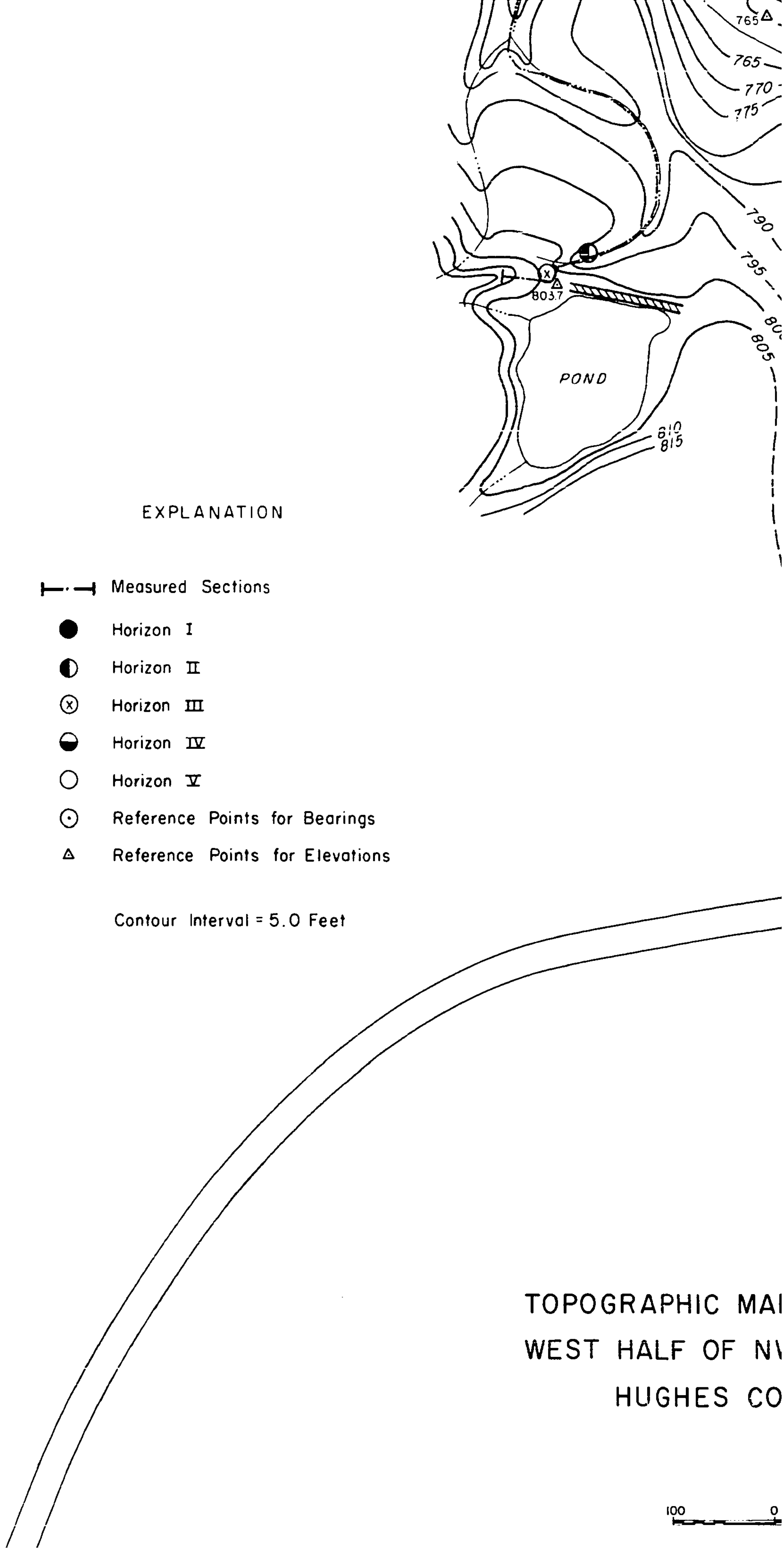
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Horizon II
Horizon III
Horizon IV
Horizon V
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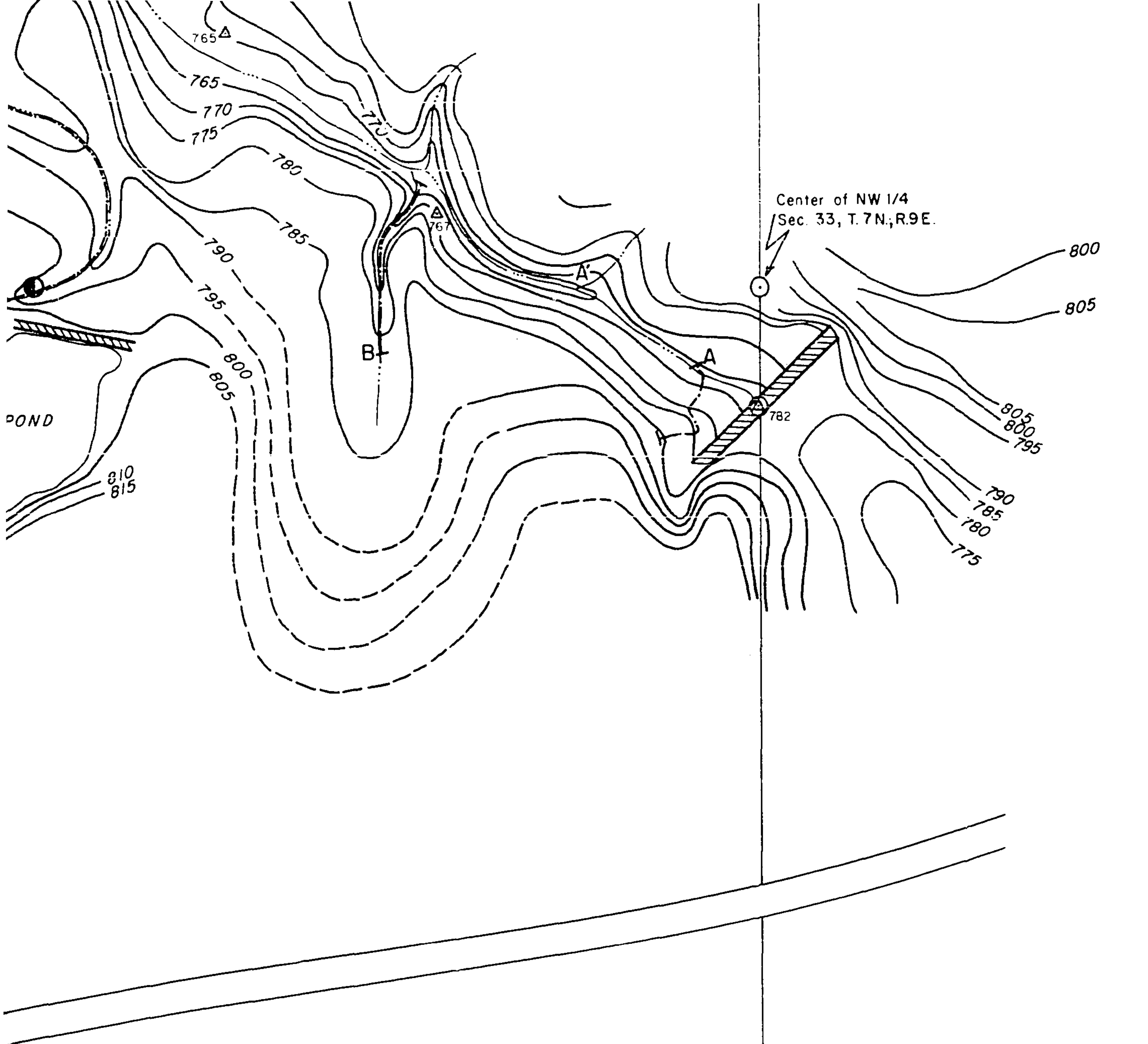
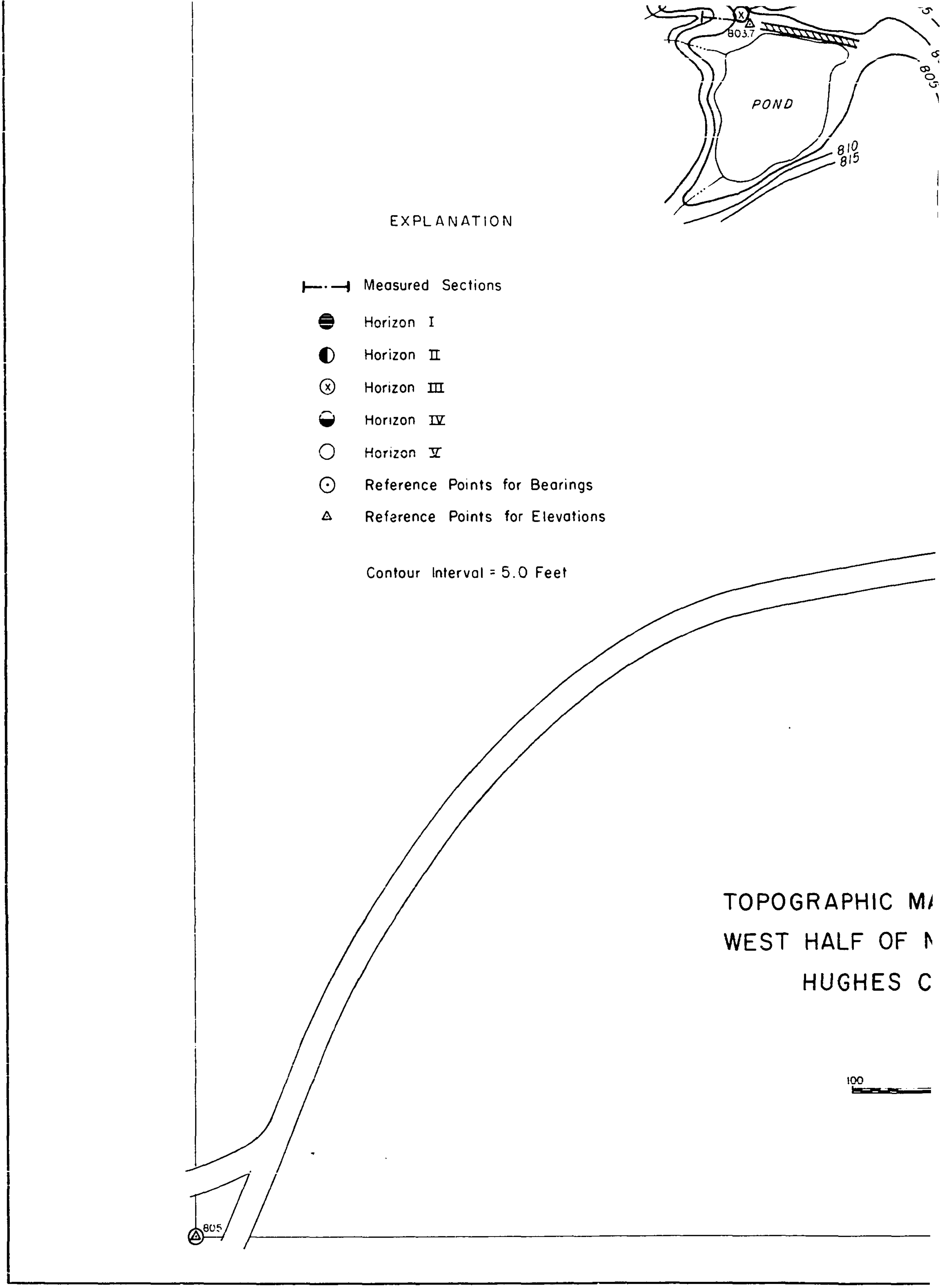


PLATE I

POGRAPHIC MAP OF A PORTION OF THE
ST HALF OF NW1/4, SEC.33, T.7N., R.9E.,
HUGHES COUNTY, OKLAHOMA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805
EXPLANATION
Measured Sections
Horizon I
Horizon II
Horizon III
Horizon IV
Horizon V
Reference Points for Bearings
Reference Points for Elevations
Contour Interval = 5.0 Feet
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HUGHES C
100
805

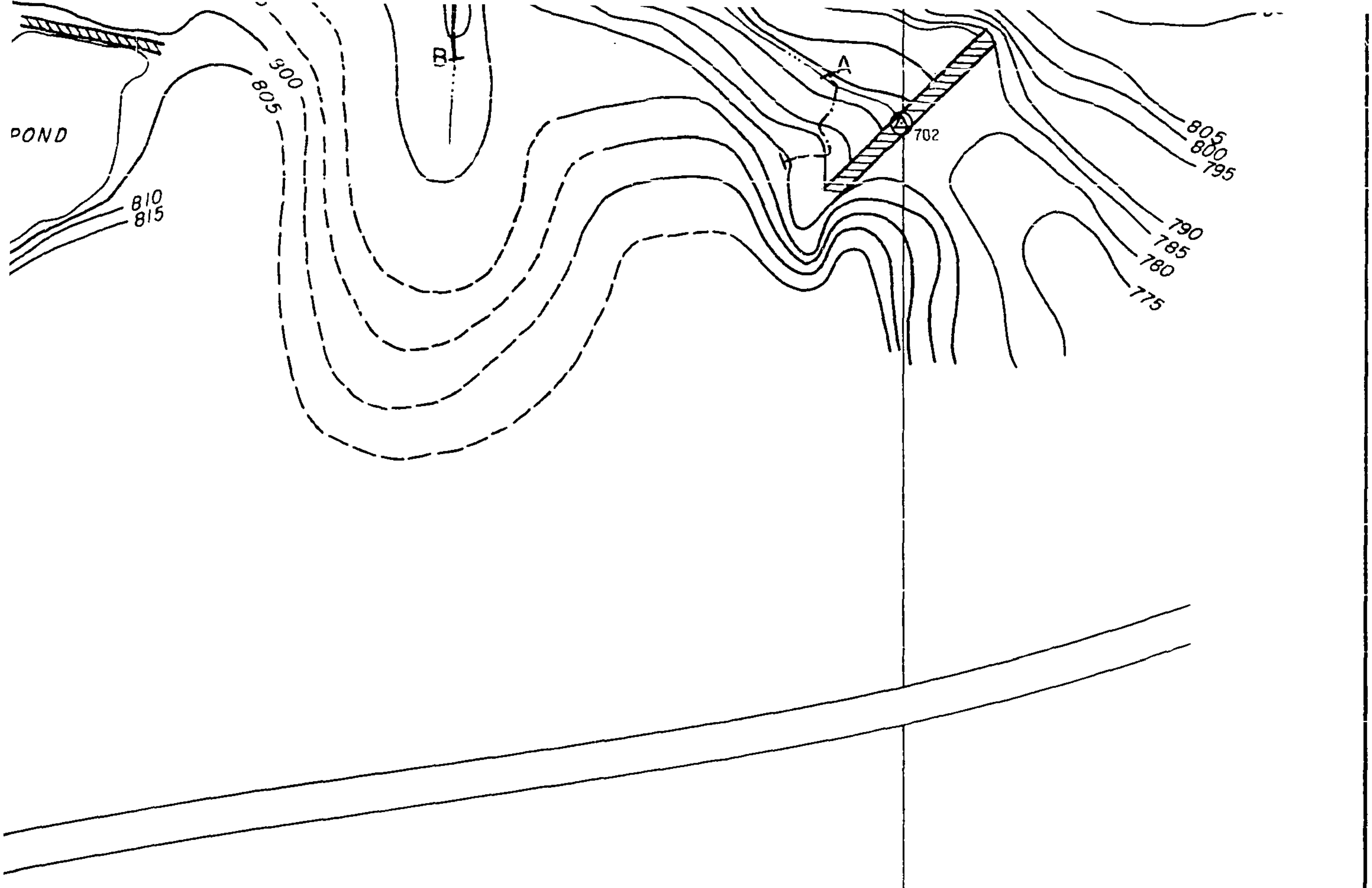
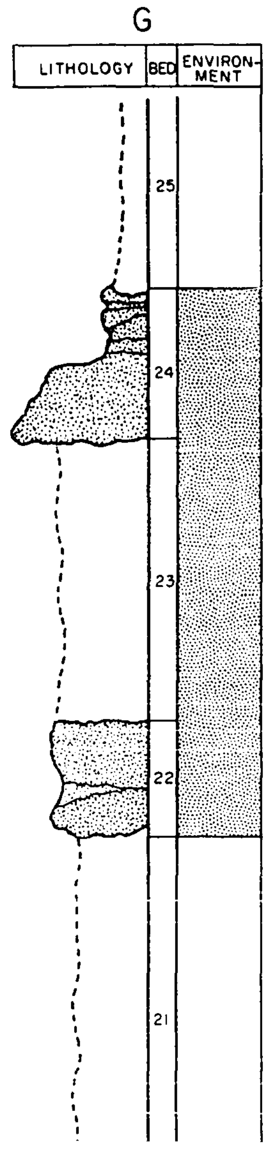
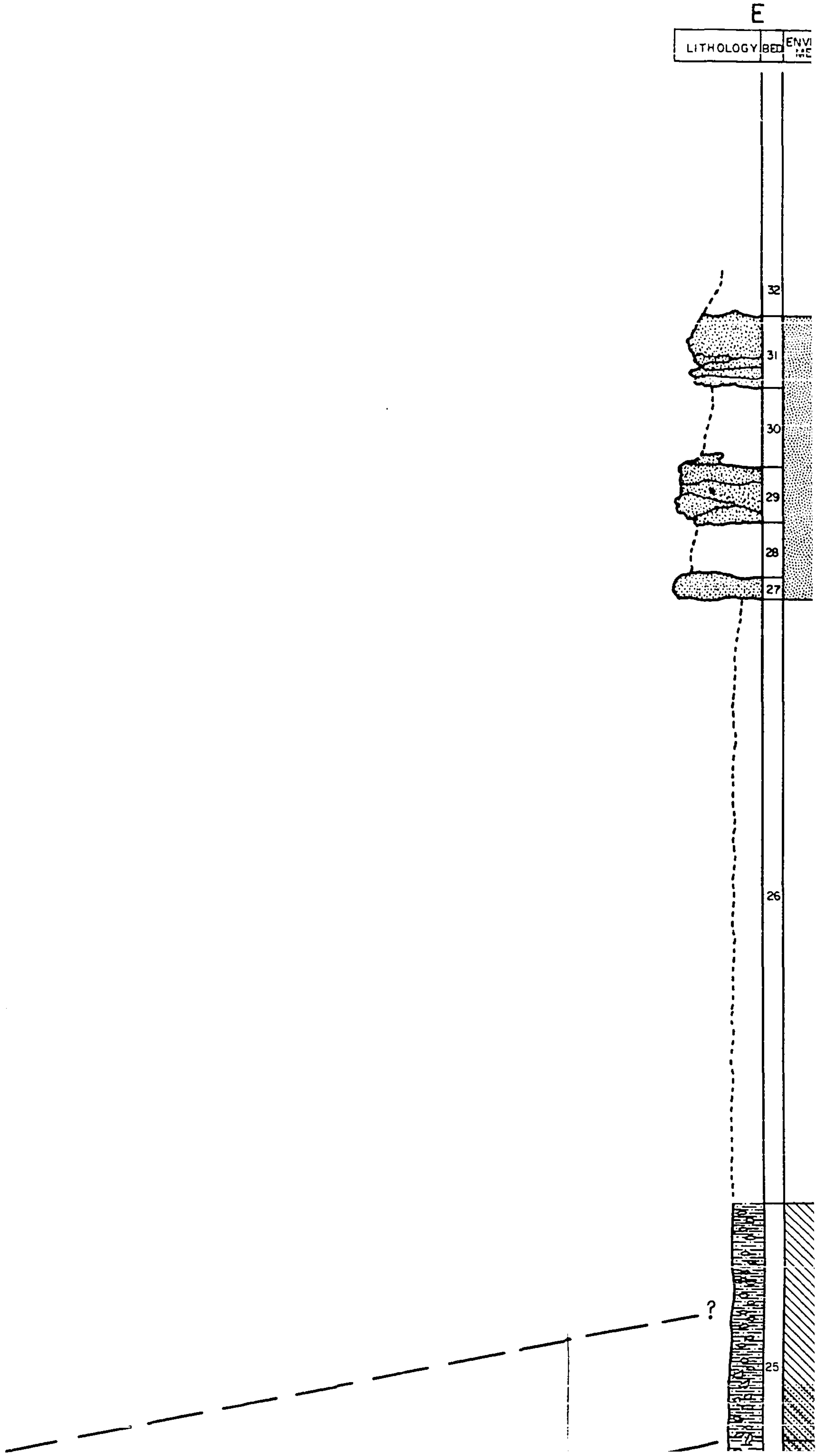


PLATE I

)POGRAPHIC MAP OF A PORTION OF THE
:EST HALF OF NW1/4, SEC.33, T. 7N., R. 9E.,
HUGHES COUNTY, OKLAHOMA

1'

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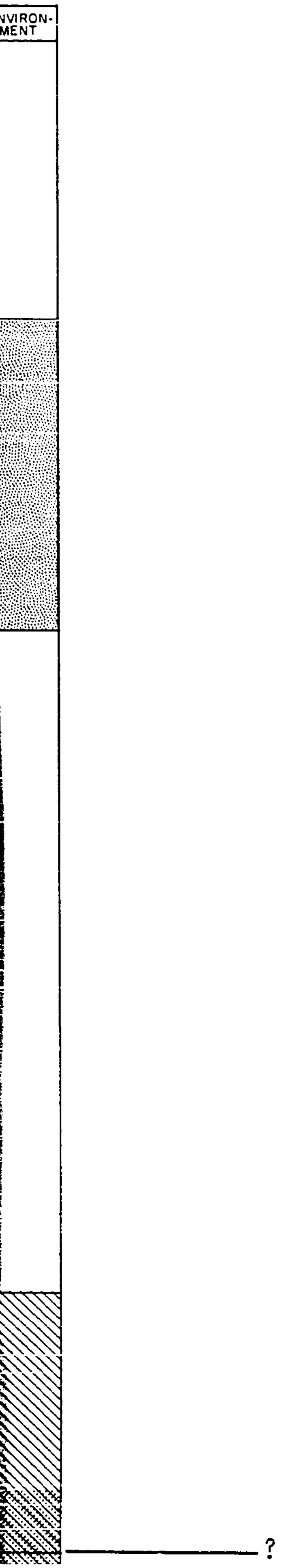
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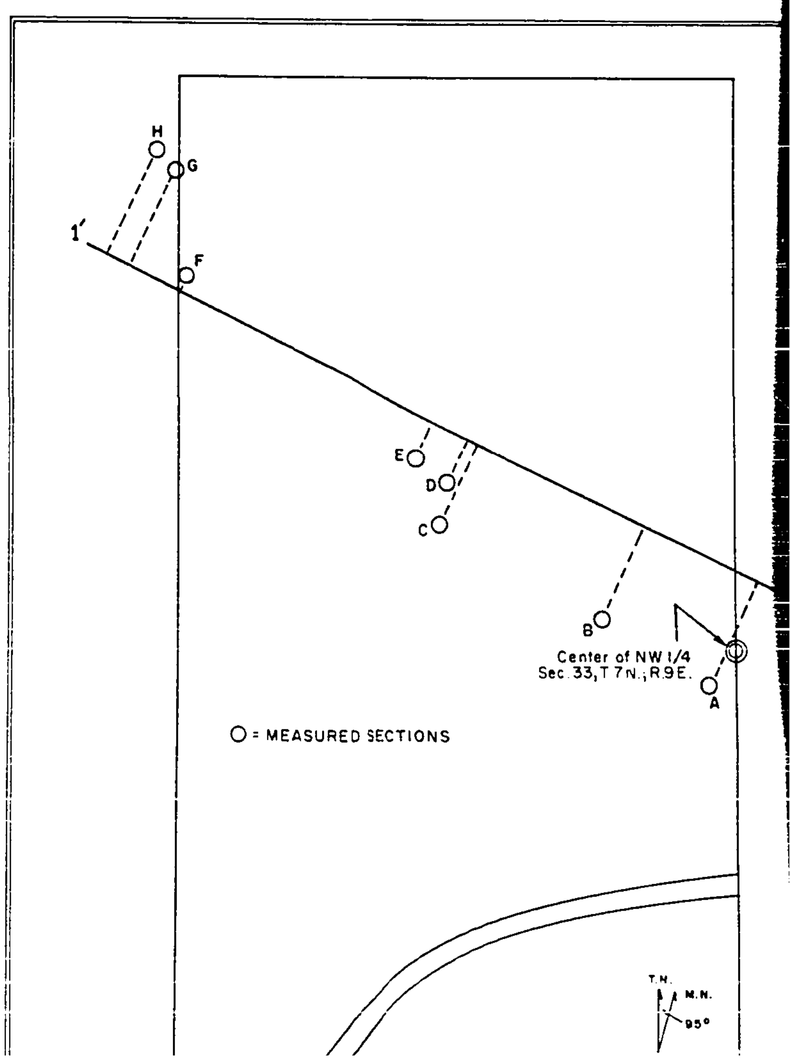
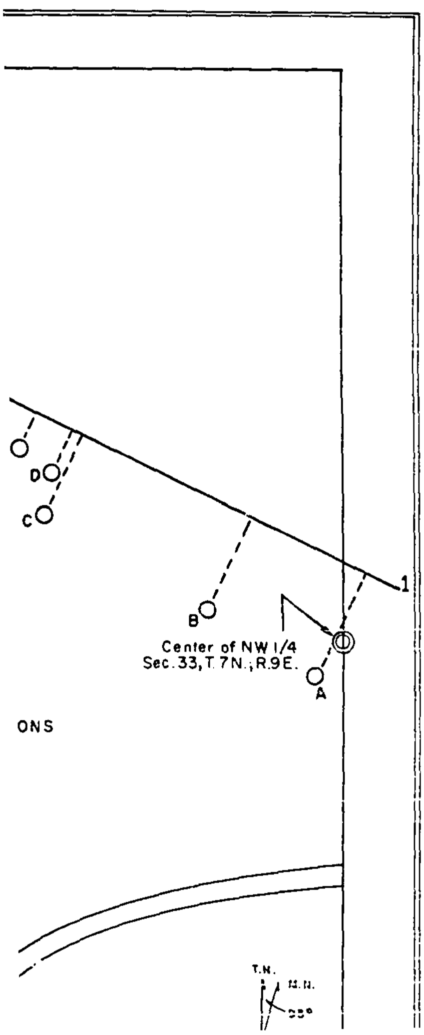

H
G
1'
F
E
D
C
B
Center of NW 1/4
Sec. 33, T 7 N., R.9 E.
A
○ = MEASURED SECTIONS
T.N.
M.N.
95°



ENVIRONMENTS

High Intertidal to Supertidal-Deltaic Area-Distributary System

Subtidal grading upwards to Intertidal-Restricted Bay to a Marshy Area in a Deltaic Plain

Subtidal ("Normal" Marine) - Central Portion of an Open Bay to a Prodelta Area

Lower Intertidal to Subtidal-Margins of a Slightly Restricted Bay to Delta Front Area

Intertidal - Tidal flat to Backswamp Marsh Area

COLLECTING STATIONS

H-773.0'	●	(HORIZON I)
C-796.2'	◐	(HORIZON II)
F-791.2'	⊗	(HORIZON III)
G-816.0'	◒	(HORIZON IV)
E-835.0'	○	(HORIZON V)

1

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d Bay to a
eltaic Plain

Marine) -
n Open Bay

Subtidal - Margins
cted Bay to

lat to Backswamp

S STATIONS

(HORIZON I)
(HORIZON II)
(HORIZON III)
(HORIZON IV)
(HORIZON V)

LITHOLOGIES

Soil

Thick to medium and thin bedded, ferrugineous, very fine to fine sand size quartz sandstone.

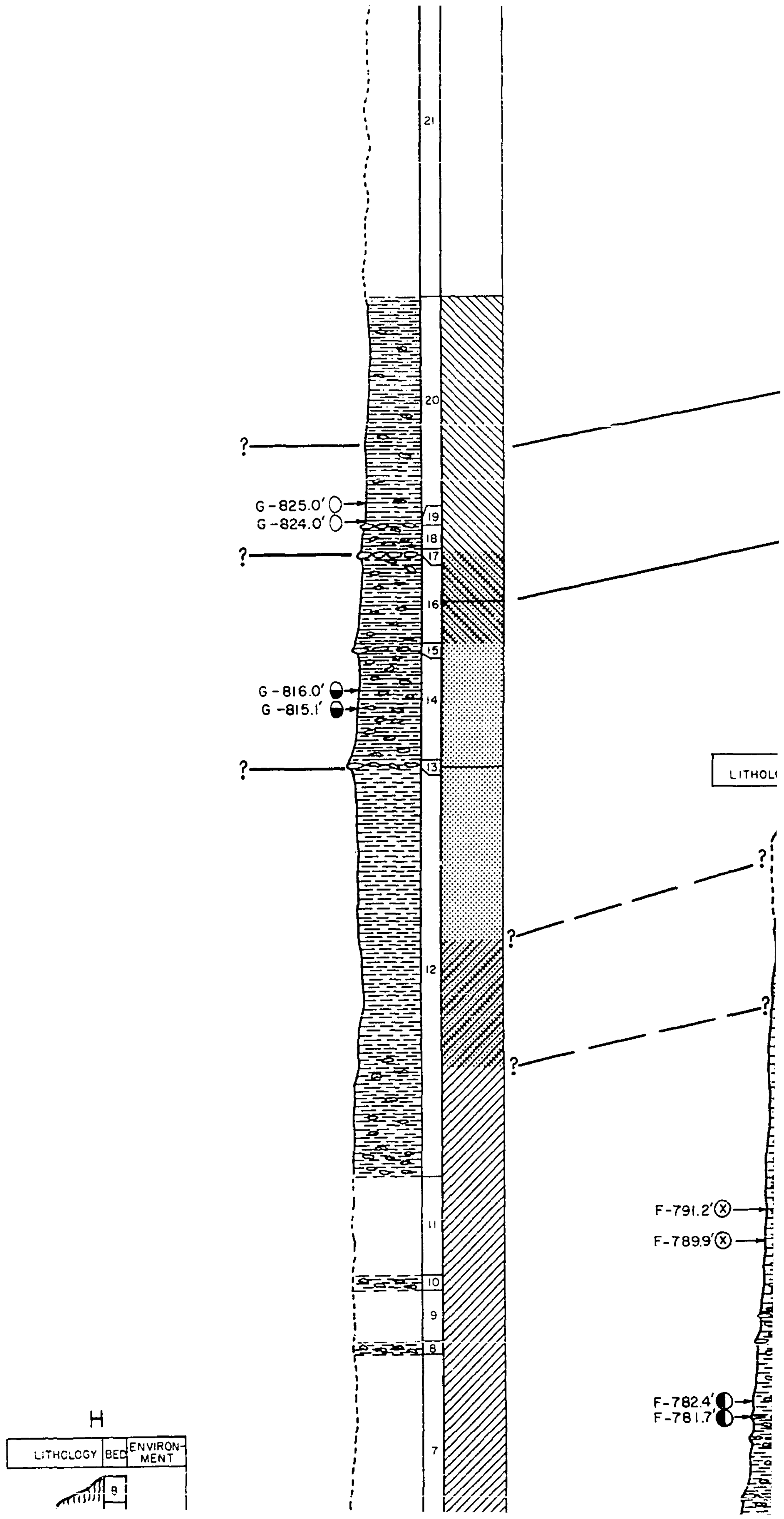
Yellowish brown, platy to blocky claystone with ironstone concretions and/or nodules. Some very fine and fine sand size to silt size quartz.

Olive gray to faint bluish gray, slightly calcareous, platy to blocky claystone with or without ironstone nodules and/or concretions.

Yellowish brown, platy to blocky claystone with or without ironstone nodules and/or concretions.

Horizon of light brown to dark yellowish orange ironstone nodules and/or concretions.

Horizons of dark gray to black, argillaceous carbonate mudstone nodules.


G-825.0'
G-824.0'
G-816.0'
G-815.1'
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14
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12
11
10
9
8
7
LITHOL
F-791.2'
F-789.9'
F-782.4'
F-781.7'
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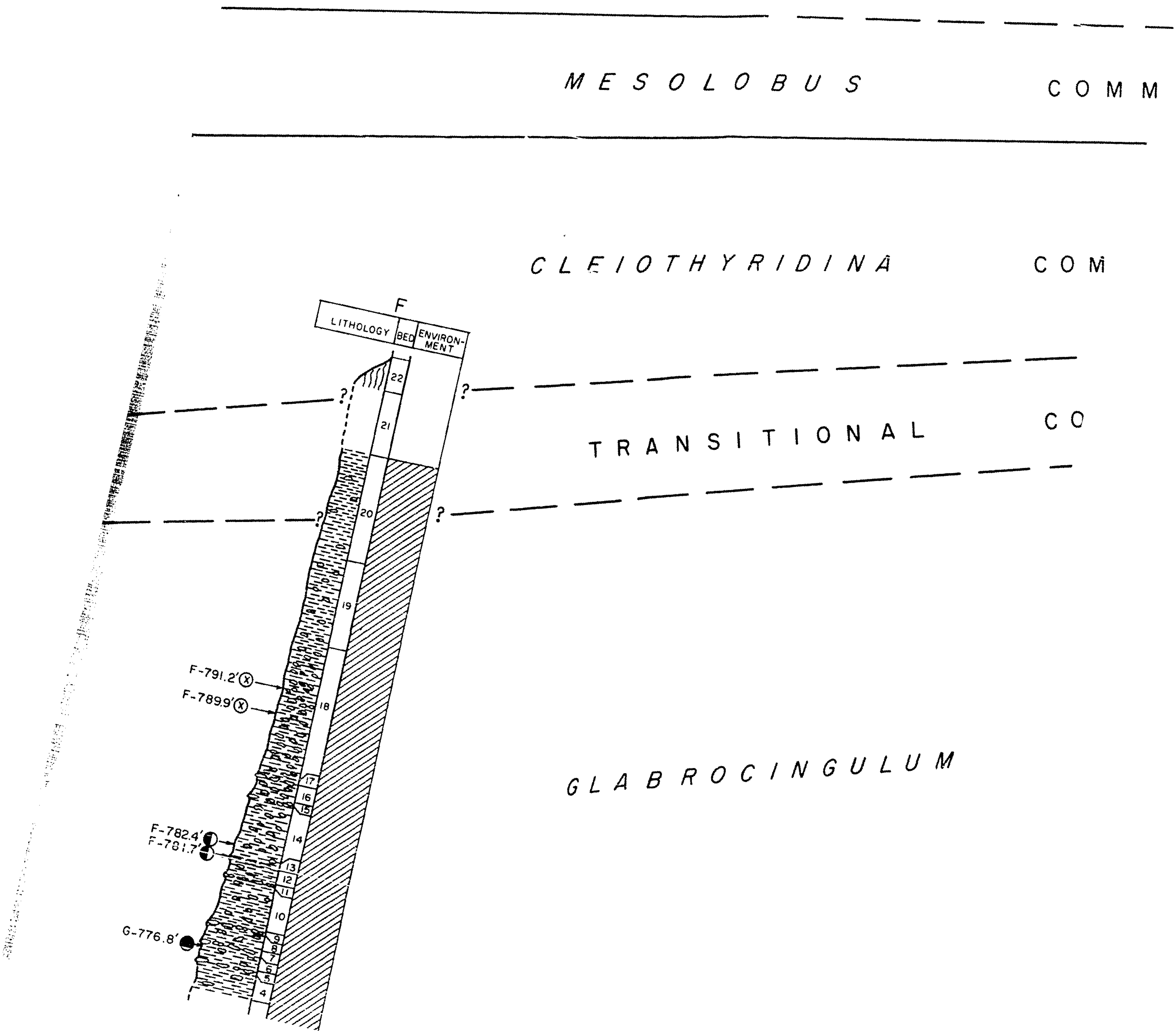
ENVIRON-MENT
8



MESOLOBUS
COMM
CLEIOTHYRIDINA
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TRANSITIONAL
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GLABROCINGULUM
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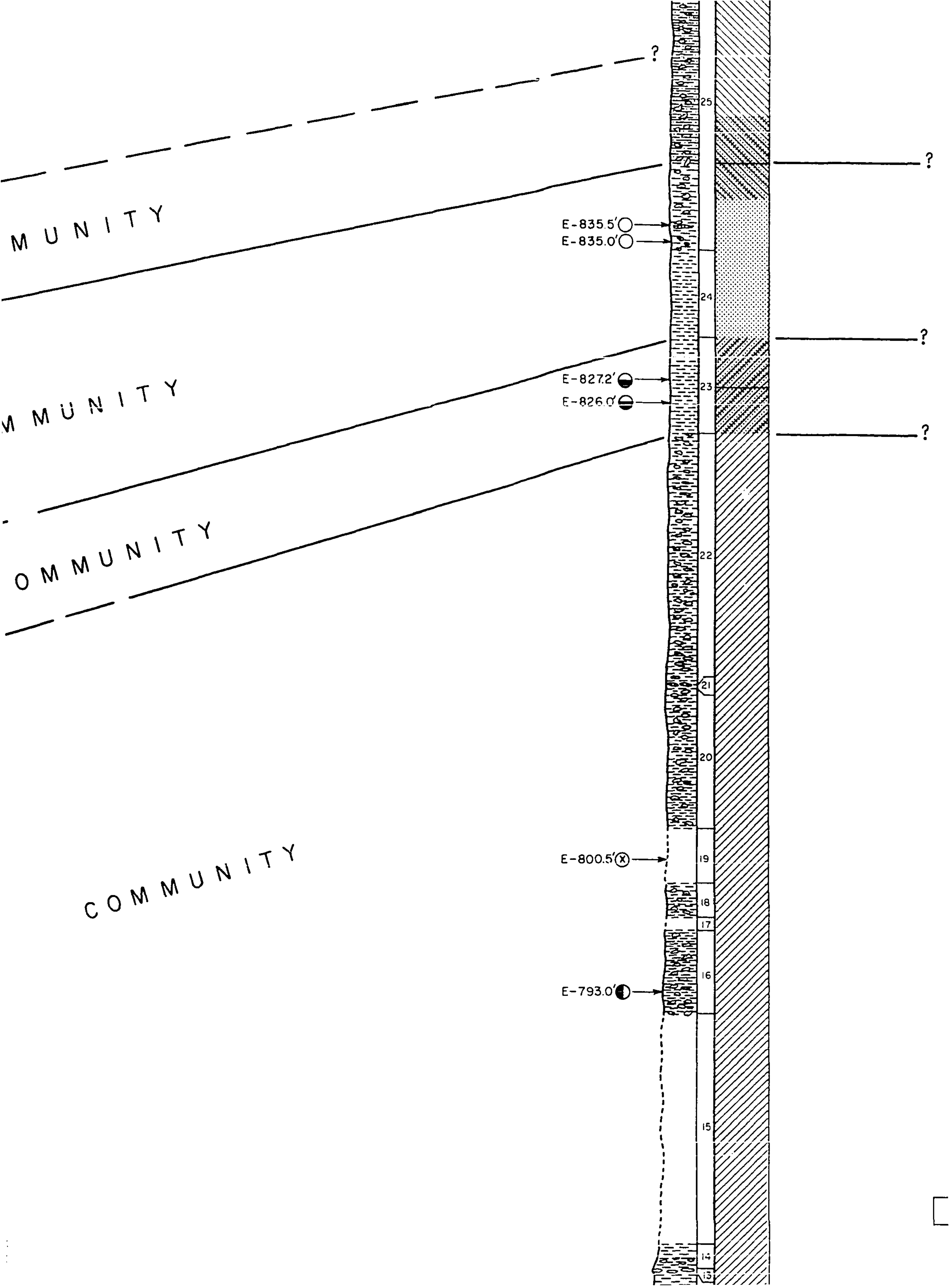
F-791.2'
F-789.9'
F-782.4'
F-781.7'
G-776.8'


MUNITY
MMUNITY
OMMUNITY
COMMUNITY
E-835.5'
E-835.0'
E-827.2'
E-826.0'
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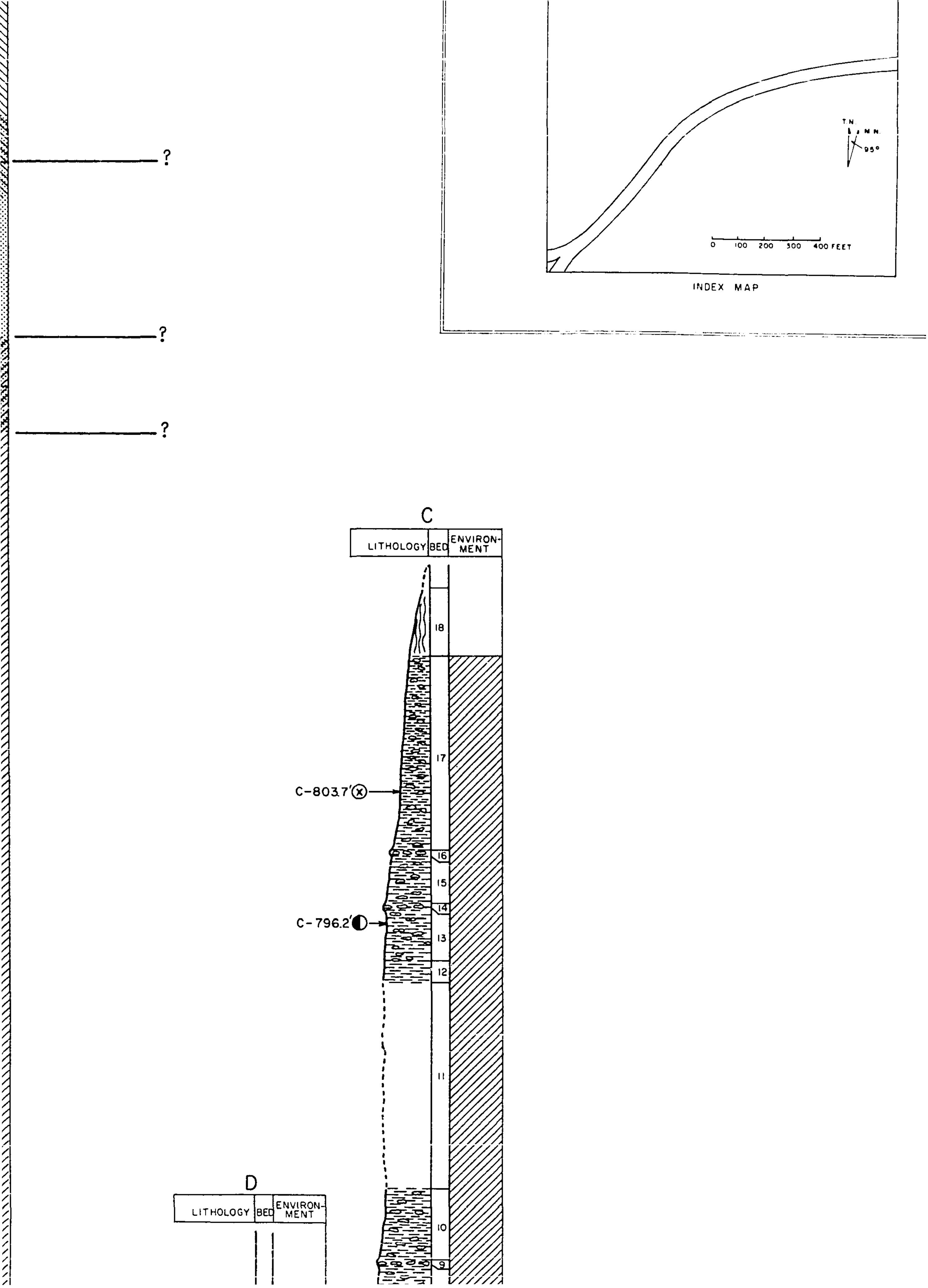
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INDEX MAP
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C-796.2′
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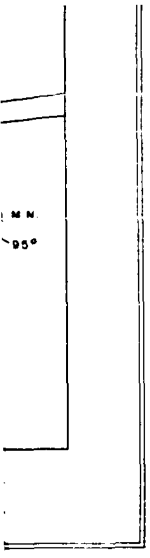
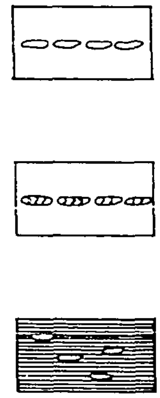
ENVIRON-MENT

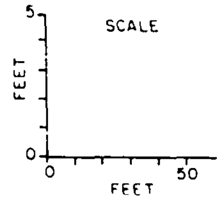


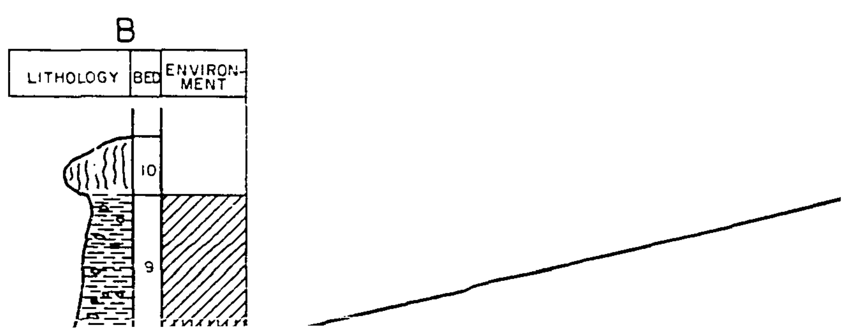
H - 773.0' ⊜ (HORIZON I)
C - 796.2' ◐ (HORIZON II)
F - 791.2' ⊗ (HORIZON III)
G - 816.0' ⊖ (HORIZON IV)
E - 835.0' ○ (HORIZON V)

?— — — Correlation Uncertain

DATUM - 770 FEET ABOVE
SEA LEVEL







(HORIZON I)
(HORIZON II)
(HORIZON III)
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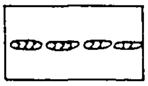
(HORIZON V)

orrelation Uncertain

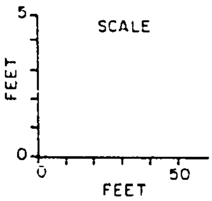
) FEET ABOVE
\ LEVEL

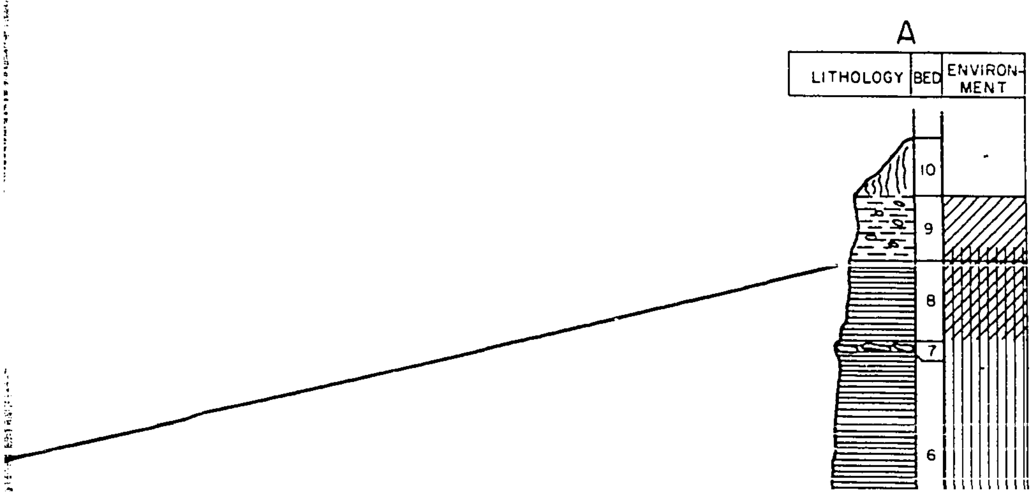
ish orange ironstone nodules and/or concretions.

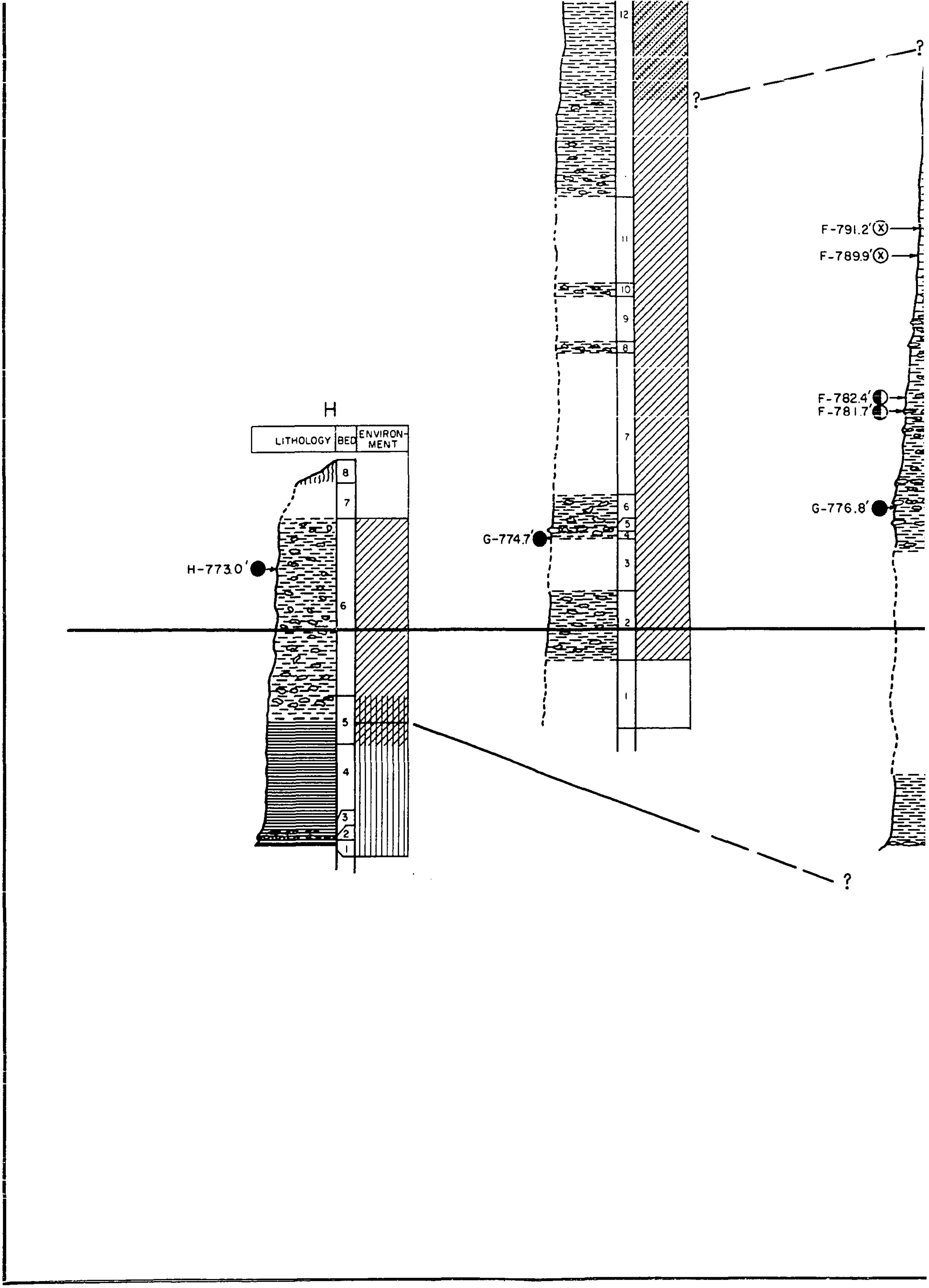


Horizons of dark gray to black, argillaceous carbonate mudstone nodules.

Dark gray to black, fissile to platy shale with or without "phosphatic" type nodules.







H
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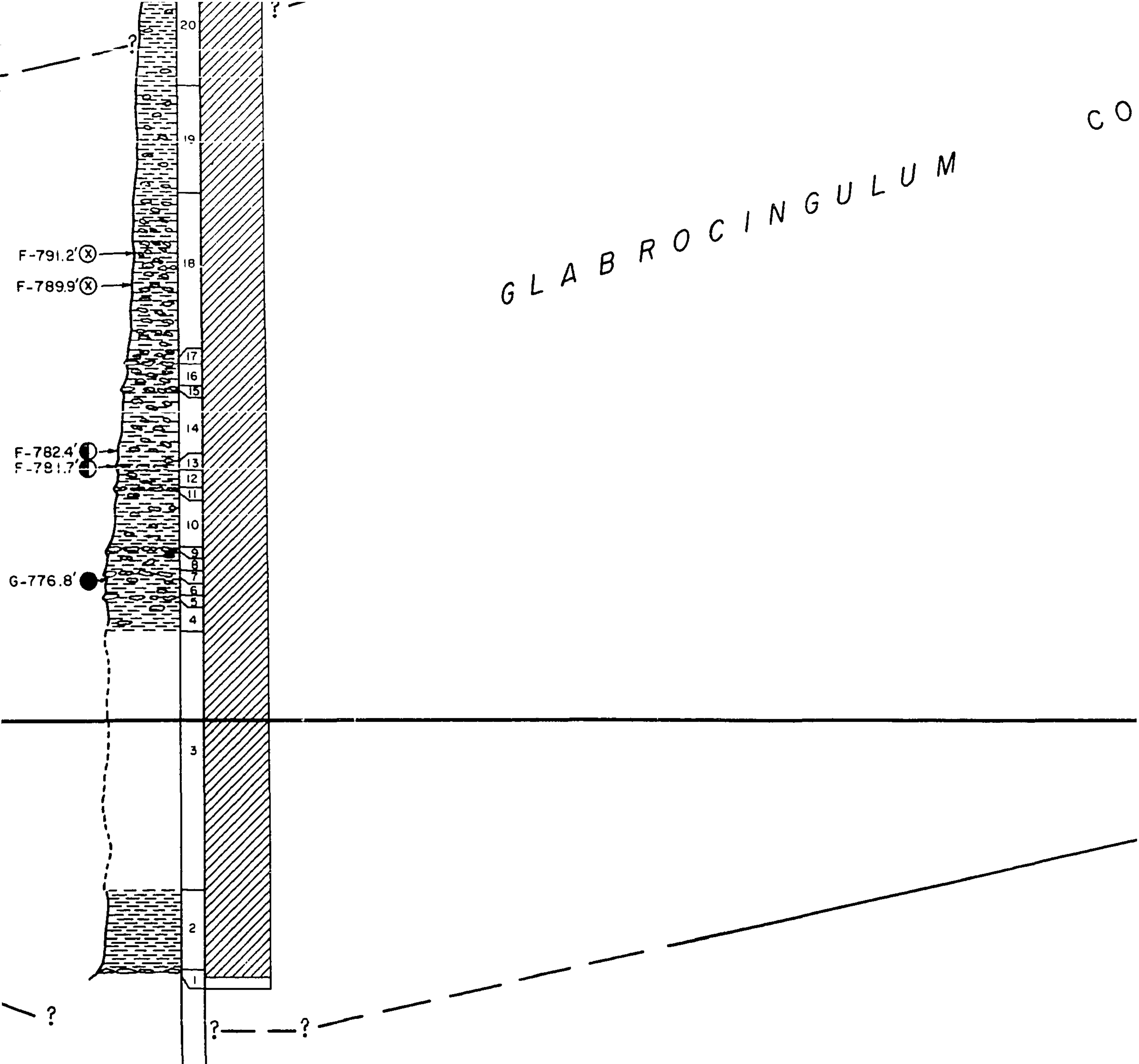
ENVIRON-MENT
H-773.0'
G-774.7'
G-776.8'
F-781.7'
F-782.4'
F-789.9'
F-791.2'



STRATIGRAPHIC

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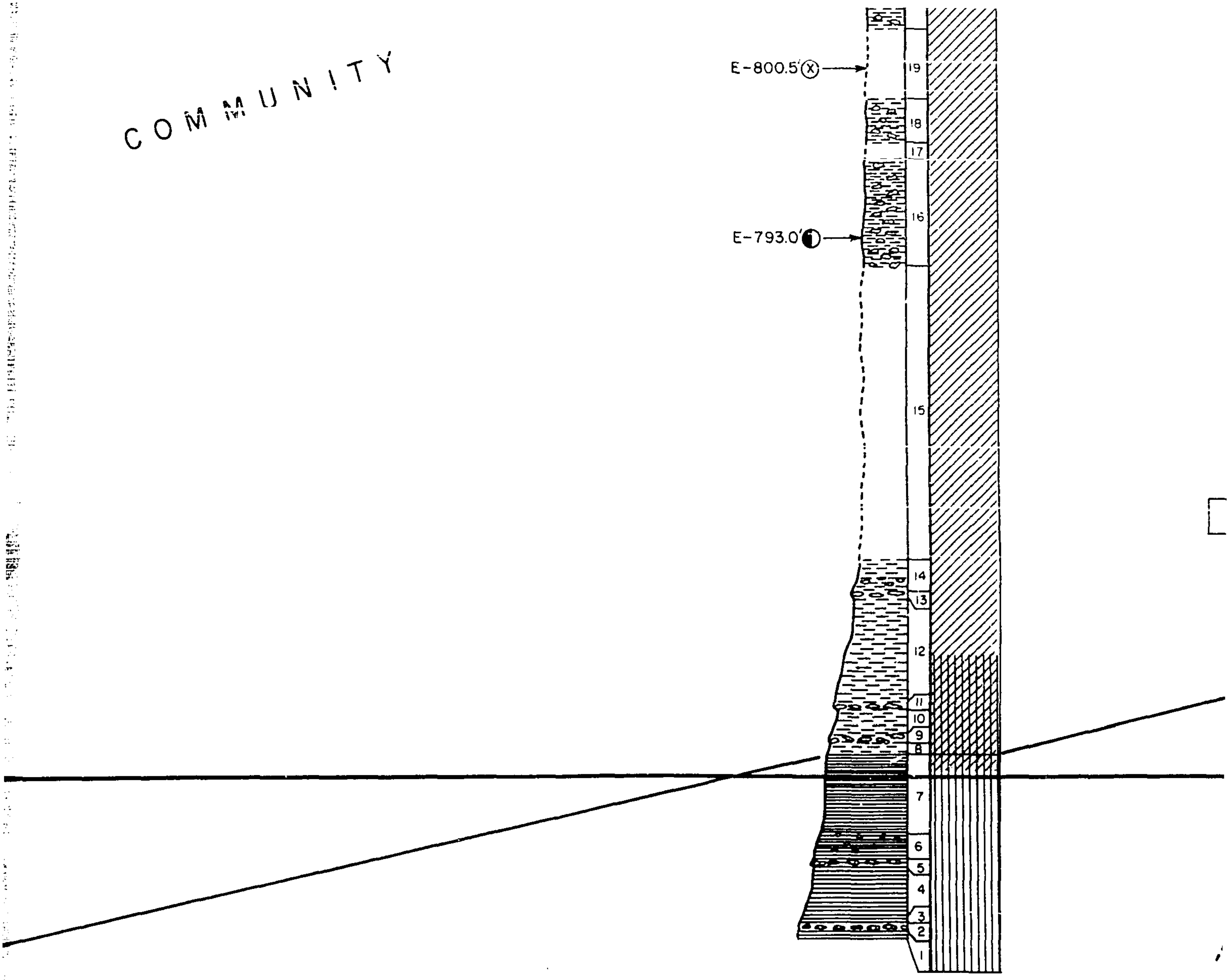


PLATE II

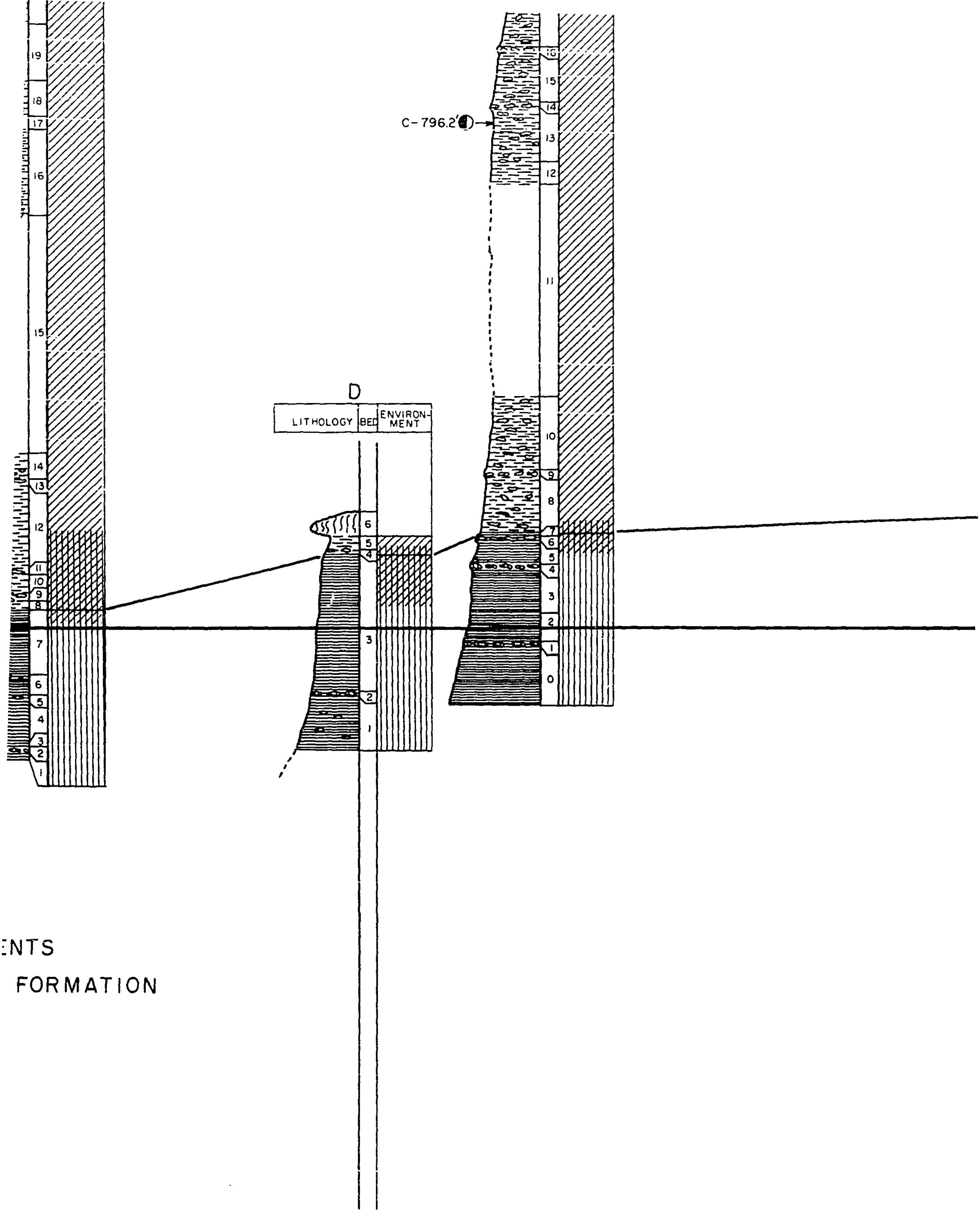
ATIGRAPHIC RELATIONSHIPS OF LITHOLOGIES, ENVIRONMENTS
THIC COMMUNITIES OF A PORTION OF THE WEWOKA FORMATION

by

Ronald R. West

Ph. D Dissertation

1970



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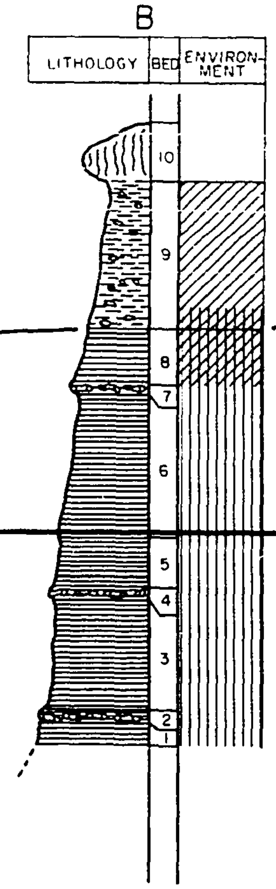
B
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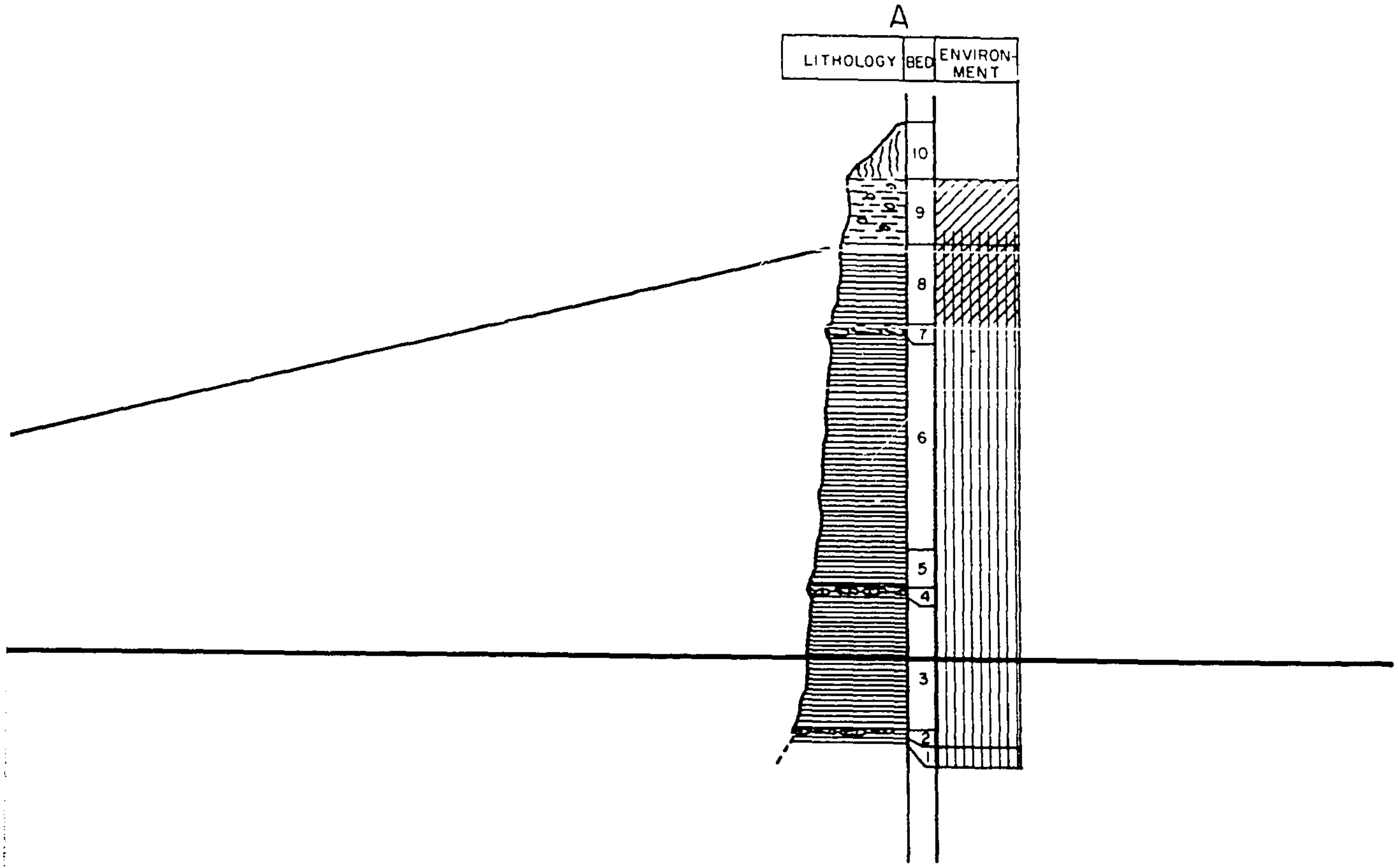
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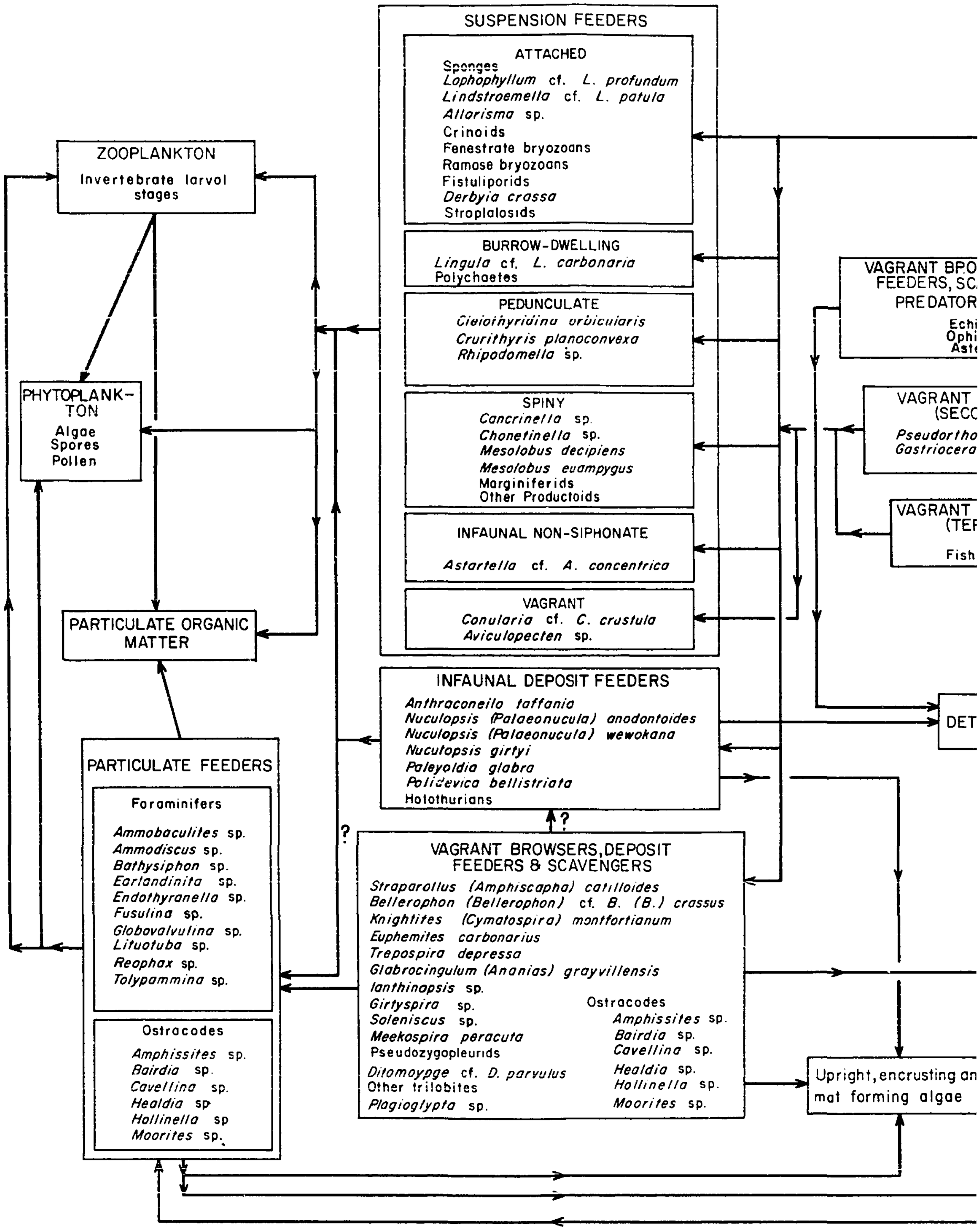

PLATE III

GENERALIZED FOOD WEB FOR THE

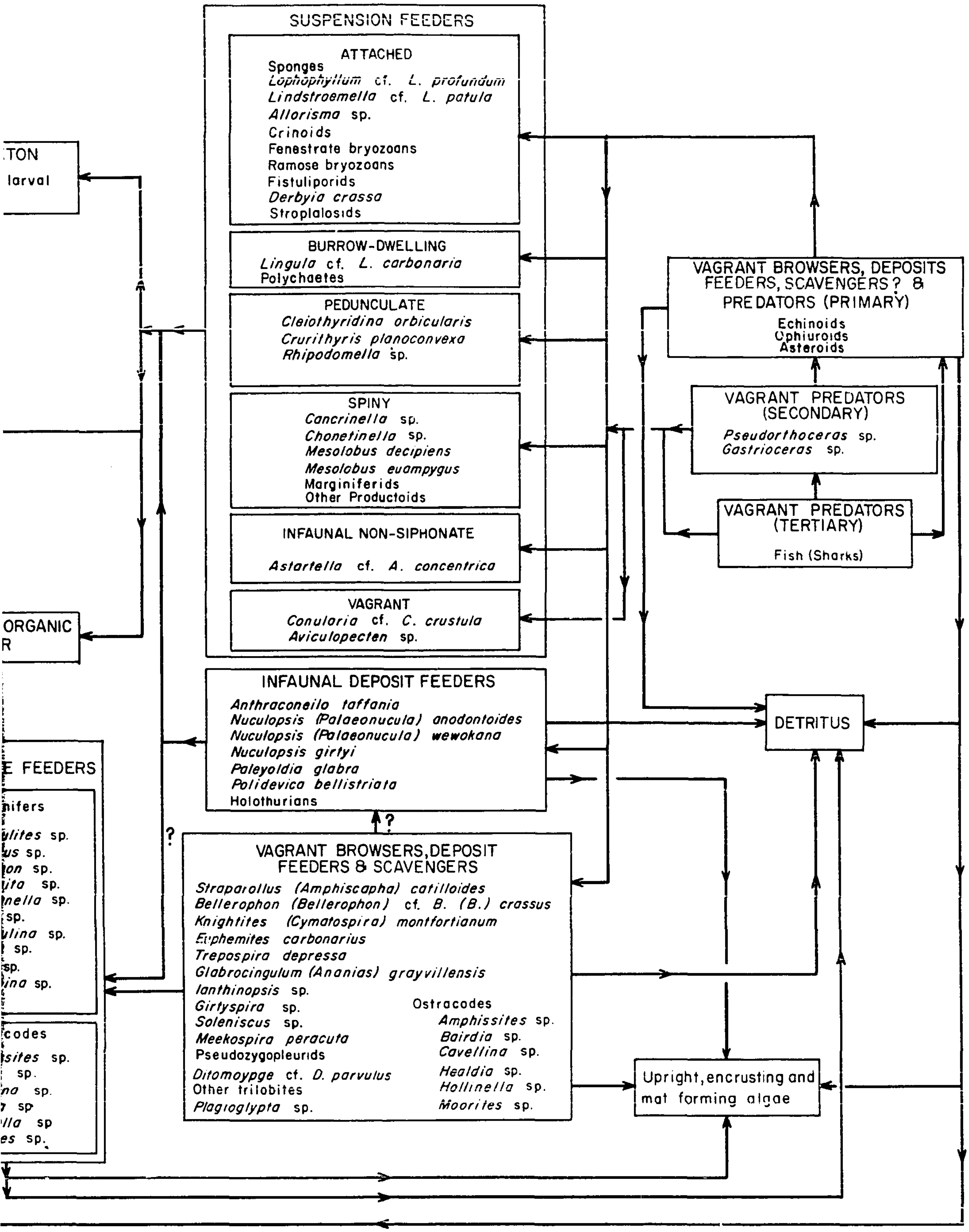

PLATE III

GENERALIZED FOOD WEB FOR THE

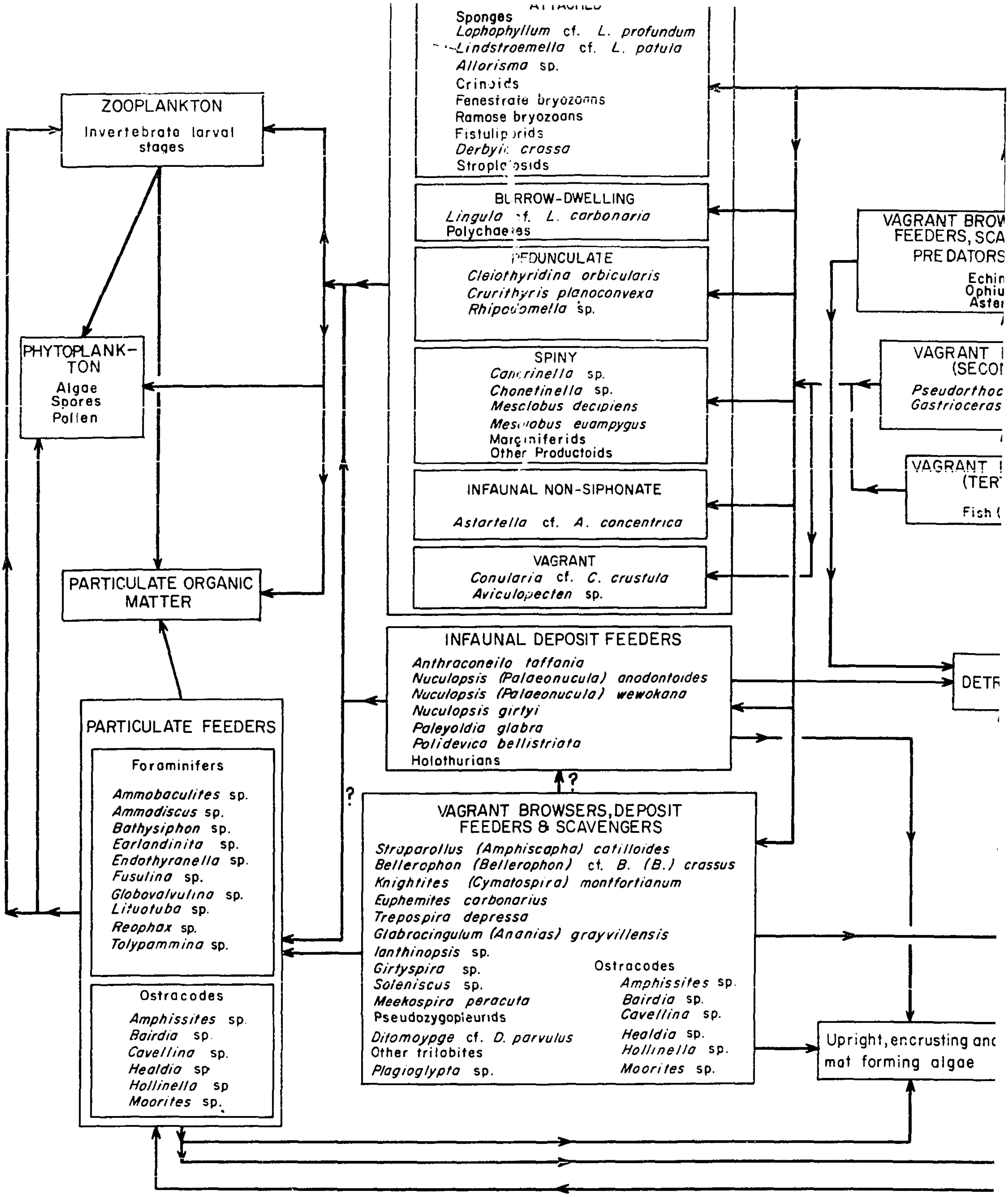

PLATE III

GENERALIZED FOOD WEB FOR THE FOUR MARINE COMMUNITIES OF THE WEWOKA FORMATION

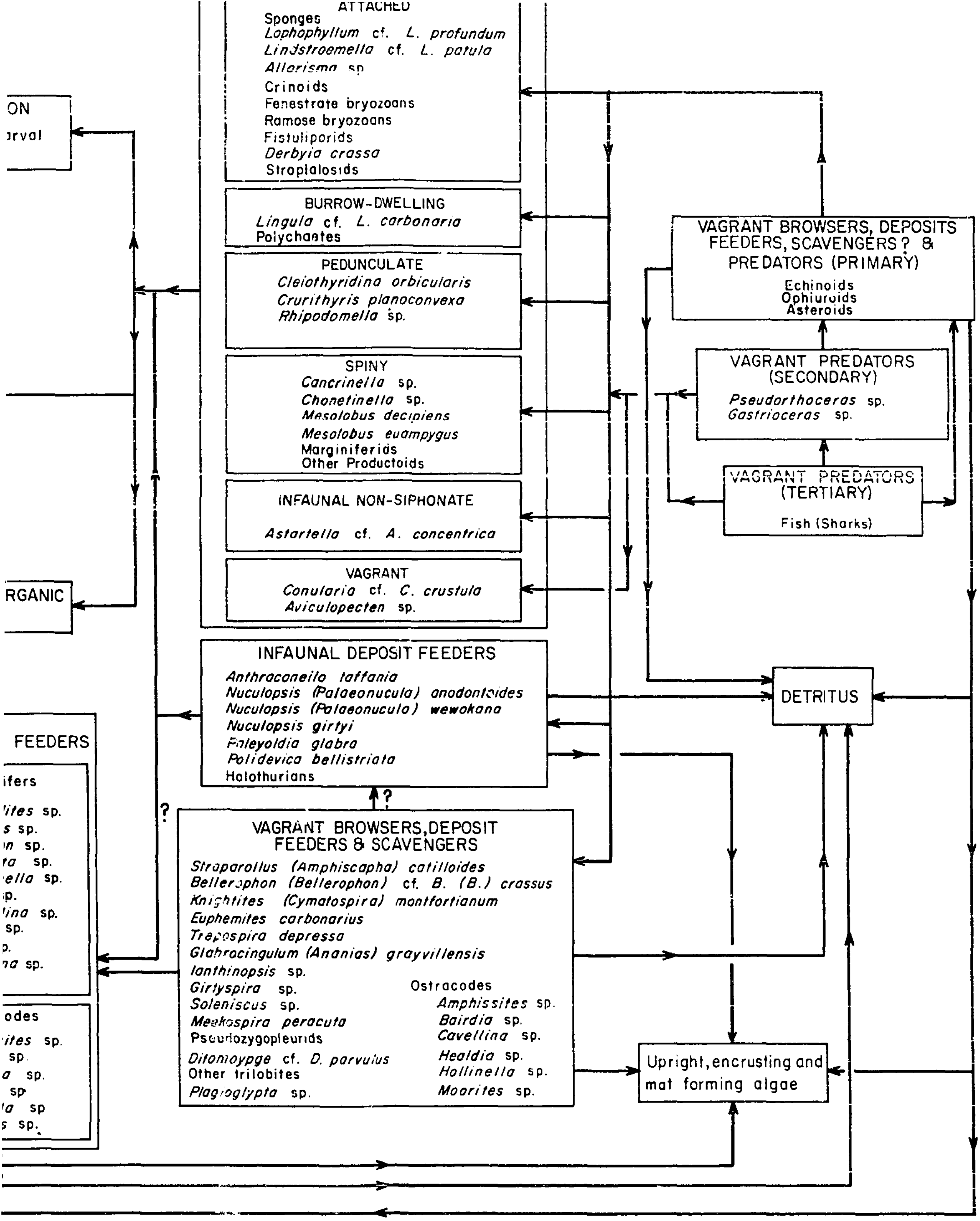

PLATE III

GENERALIZED FOOD WEB FOR THE FOUR MARINE COMMUNITIES OF THE WEWOKA FORMATION