PALEOECOLOGIC STUDY OF PART OF THE HUGHES CREEK SHALE (LOWER PERMIAN) IN NORTH-CENTRAL, KANSAS

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INTRODUCTION

Purpose of Investigation

This investigation is a study of the vertical and lateral changes in the depositional environment and paleoecology of a part of the Hughes Creek Shale Member of the Foraker Limestone in Pottawatomie, Riley, and Wabaunsee Counties, Kansas. It was undertaken to determine 1) vertical differences in biota and petrology and 2) effects of the Nemaha Anticline on the biota and petrology as suggested by West (1972) for the Crouse Limestone Formation.

A problem encountered in studying a mudstone-limestone sequence is obtaining comparable data, particularly biotic, from these two lithologies. In an effort to obtain comparable data I investigated the mudstones and Winfried Schmidt examined the limestones in the same stratigraphic interval at the same localities using similar techniques.

Location

After extensive reconnaissance, five sites (fig. 1) were chosen. Two localities are near the axis of the Nemaha Anticline (Deep Creek and Louisville), one is on the east flank (Paxico), and two are on the west flank (Blue River and Westmoreland). The Hughes Creek Shale (fig. 2) was chosen because 1) it was exposed on both sides and near the axis of the anticline, 2) it contains a diverse fossil assemblage, 3) I have previously investigated this unit, and 4) it is near Manhattan.

Previous Investigations

Condra (1927) named the Hughes Creek Shale Member of the Foraker Limestone for exposures along Hughes Creek in Nemaha County, Nebraska. Mudge and Yochelson (1962) described the stratigraphy and fossils of the

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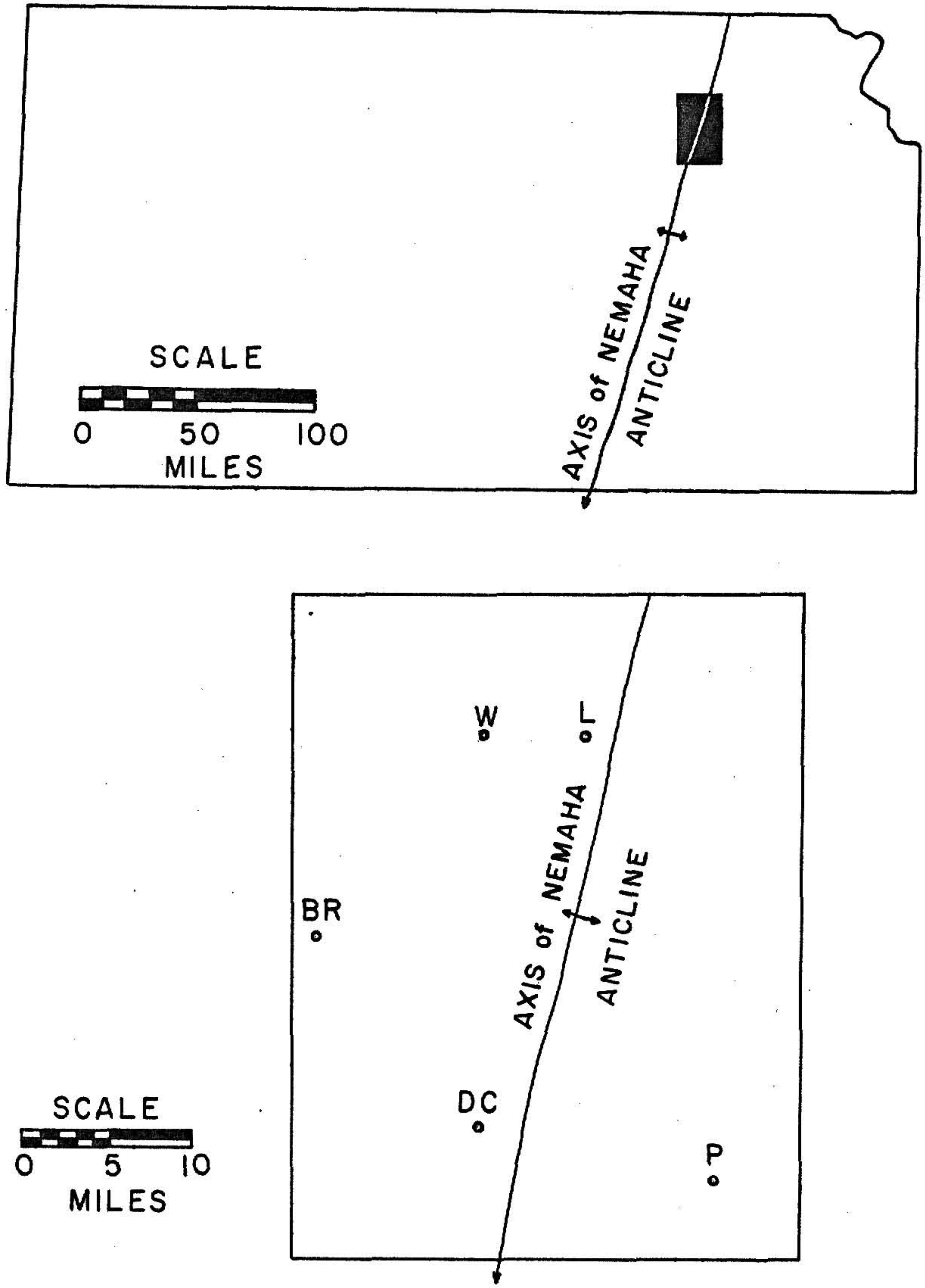


Figure 1. Geographic Area of Study

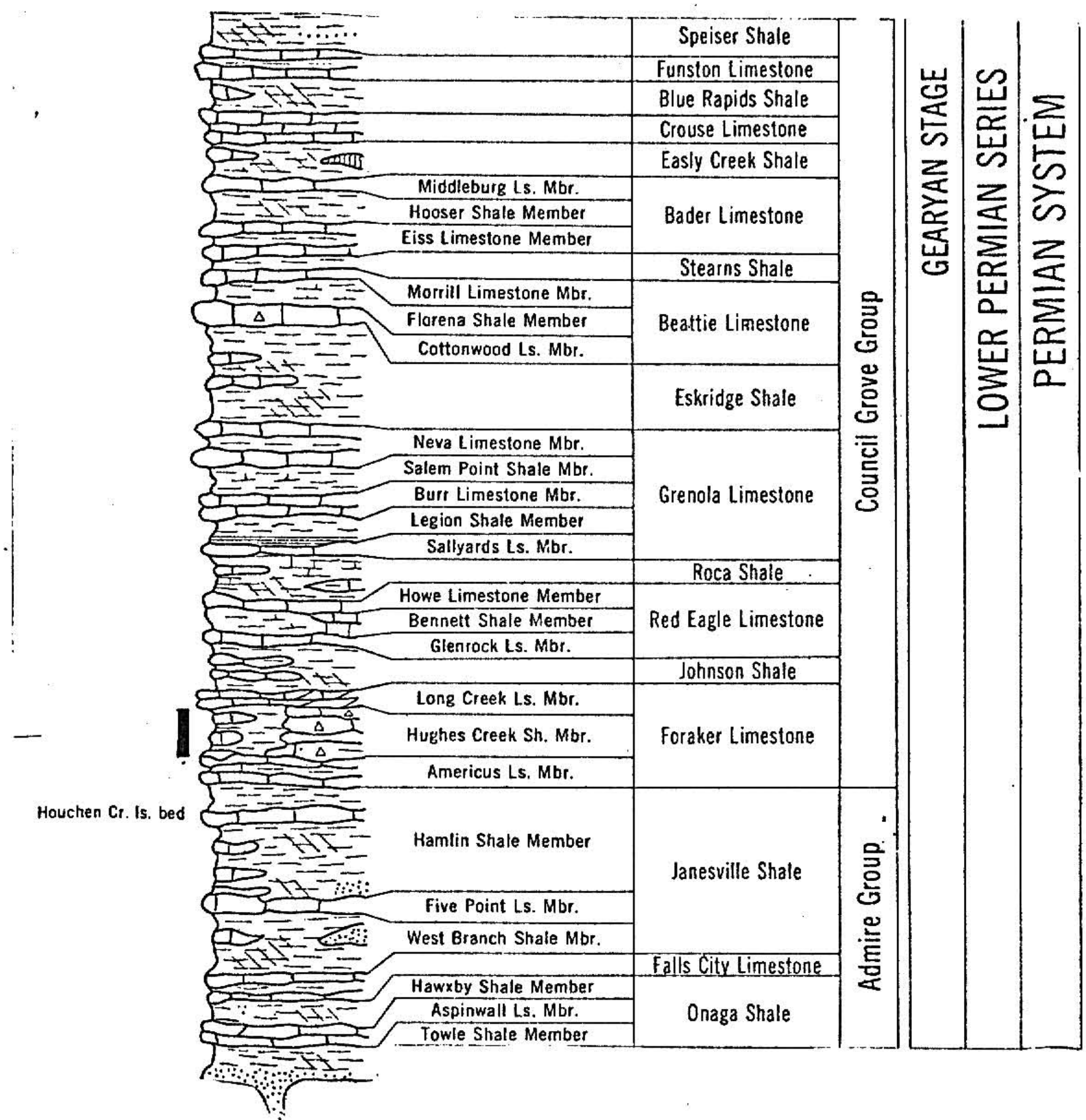


Figure 2. Stratigraphic Interval (from Zeller, 1968).

Hughes Creek Shale across Kansas. Stratigraphy of the Hughes Creek Shale in Wabaunsee, Lyon, and Chase Counties was studied by Garber (1956). Conodonts of the Hughes Creek Shale in Wabaunsee and Riley Counties were investigated by Little (1962) whereas Fisher (1970) studied fusulinids in the upper part of this unit.

METHODS OF INVESTIGATION

Field Procedure

Reconnaissance.--A reconnaissance of Hughes Creek Shale exposures in North Central Kansas was made to locate suitable outcrops. Criteria necessary to qualify for study were: 1) a complete section of the Foraker Limestone and 2) close proximity to the Nemaha Anticline. I preferred a relatively "fresh" outcrop because I believe weathering could produce significant petrologic differences in the rock. Initially, geologic maps (Mudge and Burton, 1959; Scott, Foster, and Crumpton, 1959; and Jewett, 1941) of Wabaunsee, Pottawatomie, and Riley Counties, were studied to locate possible outcrop areas. Each potentially usable outcrop was examined in the field and five were selected for study. These outcrops included two on the west flank of the Nemaha Anticline, one on its east flank, and two near its axis. Localities were named for nearby geographic and political features with first letter designations as follows: W=Westmoreland, L=Louisville, BR=Blue River, DC=Deep Creek, and P=Paxico.

Description of Stratigraphy.--The complete Foraker Limestone was described, but only data for the interval selected for study are recorded in Appendix I. Measurements were made to the nearest centimeter, color noted according to Goddard, et al. (1963), fossils identified to genus, orientation of fossils with respect to bedding noted, inorganic constituents identified, and strike and dip of joints measured with a Brunton compass. Thickness measurements were made at two different places along the outcrop and noted. Mudstones and shales were taken apart layer by layer to observe fossils commonly removed by weathering. These data were added to that obtained by study of vertical surfaces. Weathered and unweathered surfaces of all lithologies were examined and described and small biotic and inorganic constituents identified with a hand lense. Dolomite has been reported from the Long Creek Limestone in Wabaunsee County (Garber, 1956) but application of ferric chloride stain (Kelley and Moore, 1937) in the field indicated only calcite in Foraker Limestone sections investigated by myself. However, if dolomite occurs as small grains it may not be revealed by this stain.

<u>Mapping of Structure</u>.--Structure contour maps of the Nemaha Anticline have been constructed on numerous stratigraphic horizons using different contour intervals. Cole (1962) using a 500 foot contour interval, mapped the top of the Precambrian rocks and Merriam, Winchell, and Atkinson (1958) mapped the top of the Lansing Group using a 50 foot contour interval. None of the available maps were accurate for my purposes and I constructed a structure contour map on the top of the Americus Limestone Member of the Foraker Limestone using a 20 foot contour interval. Outcrops of the Americus Limestone were located on geologic maps of Pottawatomie, Wabaunsee, and Riley Counties and these locations transferred to 7 1/2 minute U. S. Geological Survey topographic maps. Initially, I planned to obtain one control point per square mile but this was impossible in some cases because of either burial by younger strata or erosion. Elevations were obtained by measuring vertical distance (using a Wild RDS Self Reducing Tacheometer) between the Americus-Hughes Creek contact with known elevations taken from topographic maps. Thompson (1966, p. 1183) referring to vertical accuracy of U.S.G.S.

topographic maps stated:

> not more than 10 percent of the elevations tested shall be in error more than one half the contour interval.

Assuming this accuracy, 90 percent of the elevations should be in error less than ±5 feet on a map with a 10 foot contour interval. Additional elevations were obtained from the Kansas State Highway Commission. These elevations were computed to the nearest 0.1 foot, then rounded to the nearest foot. Other parts of the map were constructed using data from Swett (1959) and Bruton (1958) who contoured the top of the Tarkio Limestone and Cottonwood Limestone respectively. Harned and Chelikowsky (1945) contoured a small area near Wamego on the base of the Tarkio Limestone. Elevations obtained from these three maps were converted to elevations for my map by adding or subtracting the stratigraphic interval between them. This interval was obtained from Mudge (1949) for outcrops near the respective areas. This provided information where the Americus Limestone is absent because of erosion or where it was covered by younger strata.

Collection of Samples.--Samples at least 15 cm. by 15 cm. by bed thickness were collected. This particular size was selected because 1) I wanted to study bedding surfaces, 2) 15 cm. is the maximum width of the available diamond saw vise, and 3) a similar concurrent study of the limestones (Schmidt, in preparation) in this interval requires slabbing to obtain comparable data. Such blocks of mudstone were difficult to collect in a single piece because they easily crumble.

Use of joint patterns in the limestones above and below the mudstones proved reliable aids in collecting. These joints were used to pry unwanted limestone away from the sample and a chain saw used to cut the mudstones parallel to the joints on three sides (the fourth being the outcrop face). Rock adjacent to the sample was removed with pick and shovel so that the sample remained as a pedestal. The top and four sides of the pedestal were wrapped in burlap strips soaked in molding plaster and allowed to dry. When dry, wedges were driven under the pedestal's base breaking it loose from underlying rock. This method is similar to that employed by vertebrate paleontologists. After up direction and compass orientations were marked, blocks were removed to the laboratory.

All samples were collected from measured section localities except those of locality L which were collected 1.5 miles south of L at a "fresher" exposure.

Correlation of Stratigraphic Section

Measurements and lithologic descriptions from field notes were used to construct a graphic log for each locality. Using the top of the Americus Limestone as a datum these five stratigraphic intervals were correlated on the basis of similar sequences of lithology. Only correlation of the part of the Hughes Creek Shale Member studied in detail are shown in figure 3. The datum for this dip section is the base of the study interval. The lower bed of this study is a mudstone and the upper is an argillaceous micritic limestone. This particular interval was selected because 1) fossil assemblages described in field notes were dissimilar in the lower and upper part of the interval and 2) reasonable correlations could be made.

Even though these correlations were good, a possible error may have been incorporated. At locality DC a second argillaceous zone was observed in the upper limestone and although it was mapped and petrologic data obtained, I think it should be excluded from the study interval because correlation with the other localities is questionable.

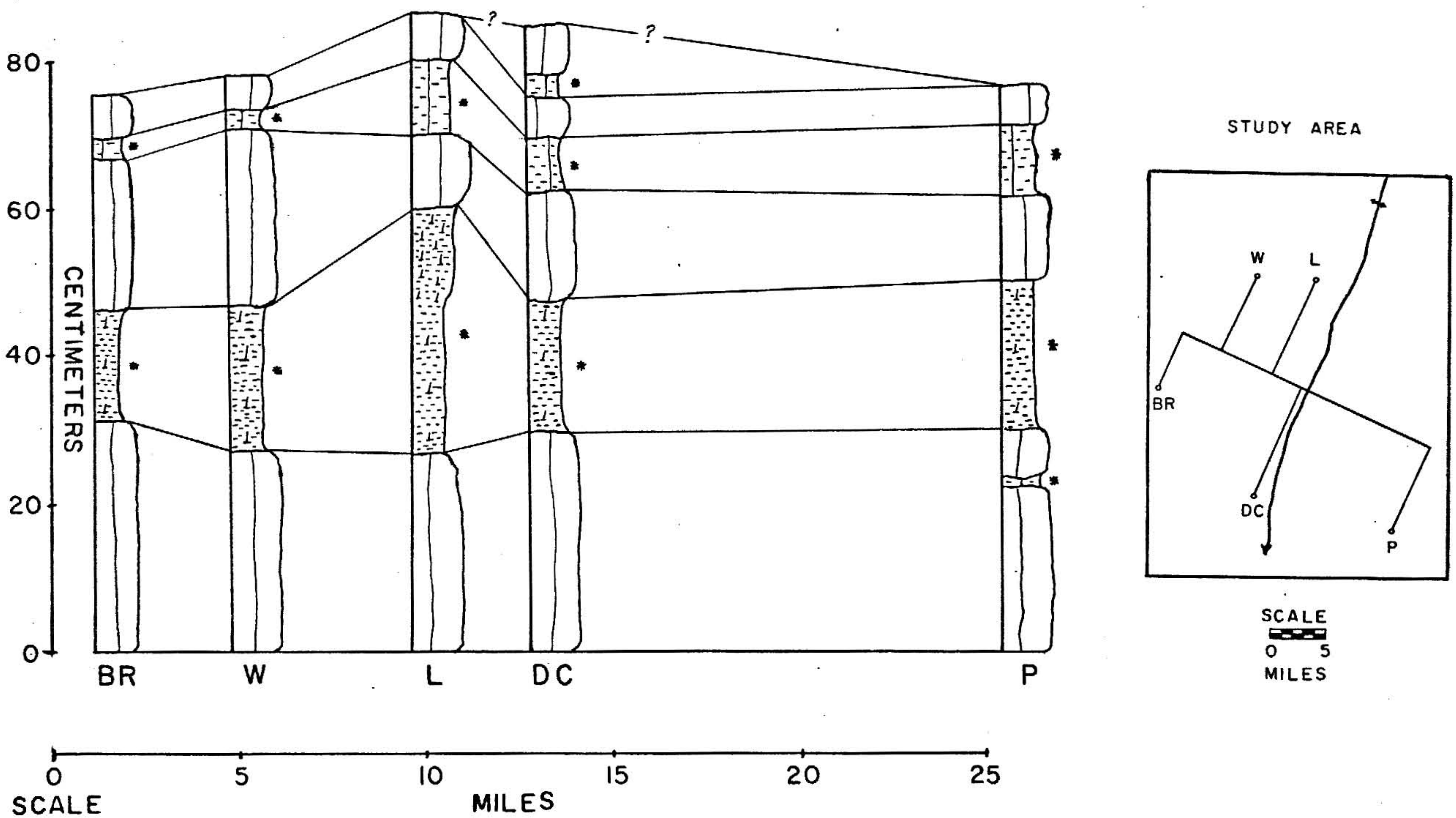


Figure 3. Correlation of Measured Sections (* = beds studied).

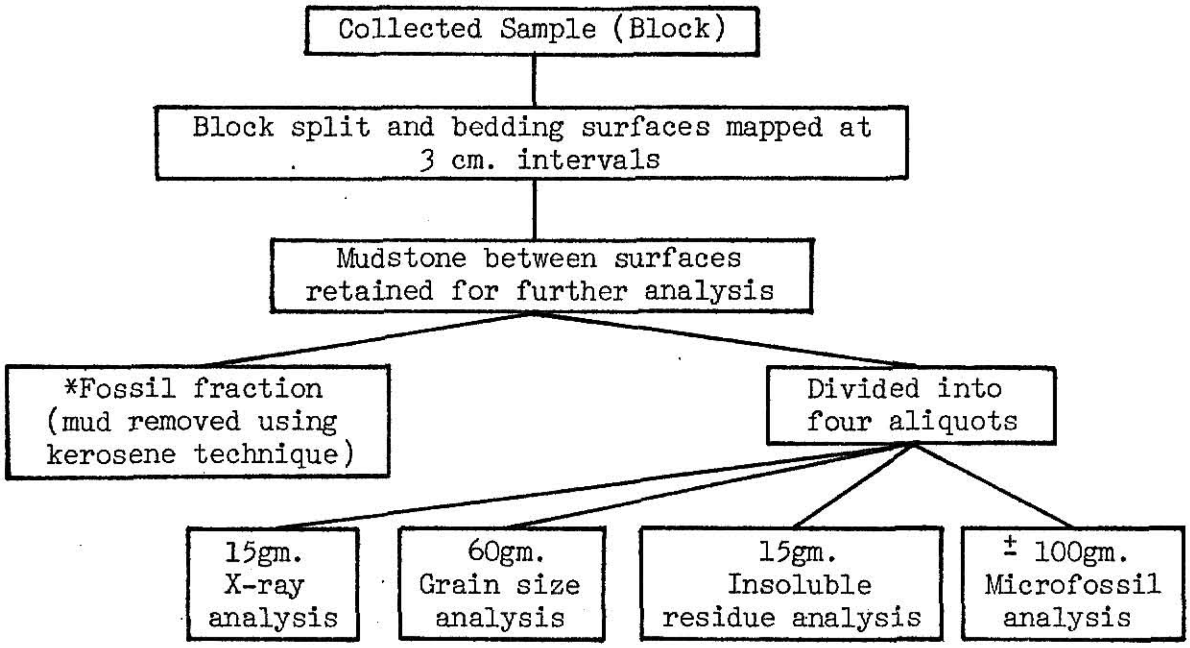
Laboratory Procedure

General Statement.--Some limestones were collected to keep the samples intact, however, only intervals that weathered similar to mudstones were studied in the laboratory. A flow of general laboratory procedure is shown in Figure 4.

Mapping of Bedding Surfaces.--The first step in analysis of samples was to map the bedding surfaces. Samples (blocks) were properly oriented (up arrow up) on a bench and the plaster-burlap cast removed. Thin limestones overlying the sample intervals were removed and the exposed surfaces mapped on 1/8 inch thick piece of plexiglas by tracing the outlines of fossils present on the plexiglas sheet with grease pencils. Each map was transferred to a separate sheet of paper for permanence (Appendix 2) and the plexiglas erased with soft tissue paper making it ready for the next surface. If the bed was less than three centimeters thick, I mapped only the top surface. For beds greater than three centimeters thick, I mapped the top surface and additional surfaces at approximately three centimeter intervals. This interval was chosen because 1) it was thicker than the greatest dimension of most fossils so they would be mapped on only one surface and 2) it would permit documentation of gradual changes in fossil content. During mapping the following were noted: 1) genus or type of fossil (*i.e.* *Crurythris*, ramose ectoprocts, burrows), 2) long and short dimension to the nearest millimeter, 3) orientation with respect to bedding *i.e.*. parallel, inclined or perpendicular), 4) orientation of concavity (*i.e.* concave or convex up), 5) articulated or disarticulated, 6) if disarticulated which valve (*i.e.* pedicle, brachial, right, or left), 7) degree of gaping of articulated valves, 8) episymbionts (*i.e.* ramose ectoprocts attached to brachiopods), 9) fragmentation, and 10) type of preservation.

Figure 4

Flow Diagram of General Laboratory Procedure



*Initially I planned to analyze and incorporate this data but time ran out.

Washed Residue Analysis.--An idea of microfossil content was obtained by disaggregating a sample three centimeters by three centimeters by the thickness between mapped surfaces (commonly three centimeters) after the surface was mapped. Three shale disaggregation techniques were tried on two different lithologies (mudstone and argillaceous micritic limestone). An aliquot of approximately 100 grams was placed in a 400 milliliter beaker, covered with water, a drop of "Micro" detergent added, and the beaker placed in a Bransonic Model 32 ultrasonic cleaner with a water level at or above the beaker liquid level. Different time intervals of ultrasonic treatment were tried after which the sample was washed through a 230 mesh (4Ø) sieve to remove the mud (clay and silt).

The method described by Zingula (1968) using Quaternary "O" was also tried. After boiling for 45 to 60 minutes, the liquid was allowed to cool and the sample washed through a 230 mesh sieve. The third method was the standard kerosene method used to disaggregate mudstones as described by Scott (1973, p. 8-11). Table 1 is a critique of these methods.

The kerosene method was used to wash all samples for microfossil data because 1) operator time was less per sample and 2) no extensive equipment was needed. Residues obtained were sieved through 10, 18, 35, and 60 mesh sieves and visual estimates of percent of different fossils in each fraction made using charts (Terry and Chilingar, 1955). This data is tabulated in Appendix II.

Insoluble Residue Analysis.--Field observations indicated that the entire interval was calcareous so an insoluble residue weight percent was calculated. Figure 5 is a flow diagram indicating the procedure followed and is a modification of one used by Scott (1973). Ten to 15 grams of rock were crushed and oven dried for 24 hours. Five grams of dried sample were

Table 1

Critique of Disaggregation Methods

	Ultrasonic	Quaternary "O"	Kerosene
Operator time per sample	Long	Long	Moderate
Effectiveness			
Mudstone	Good	Good	Good
Argillaceous micritic limestone	Bad	Poor*	Bad
Degree of fragmentation of fossils**	Moderate to high	High	High

* This could have been caused by inadequate agitation or because the samples contained too much calcite cement.

** Diagenesis produces fragmentation which is apparent when the fossils are removed. Further fragmentation occurs during final washing.

All terms used in this table are relative and based on impressions and/or visual examinations of washed residues.

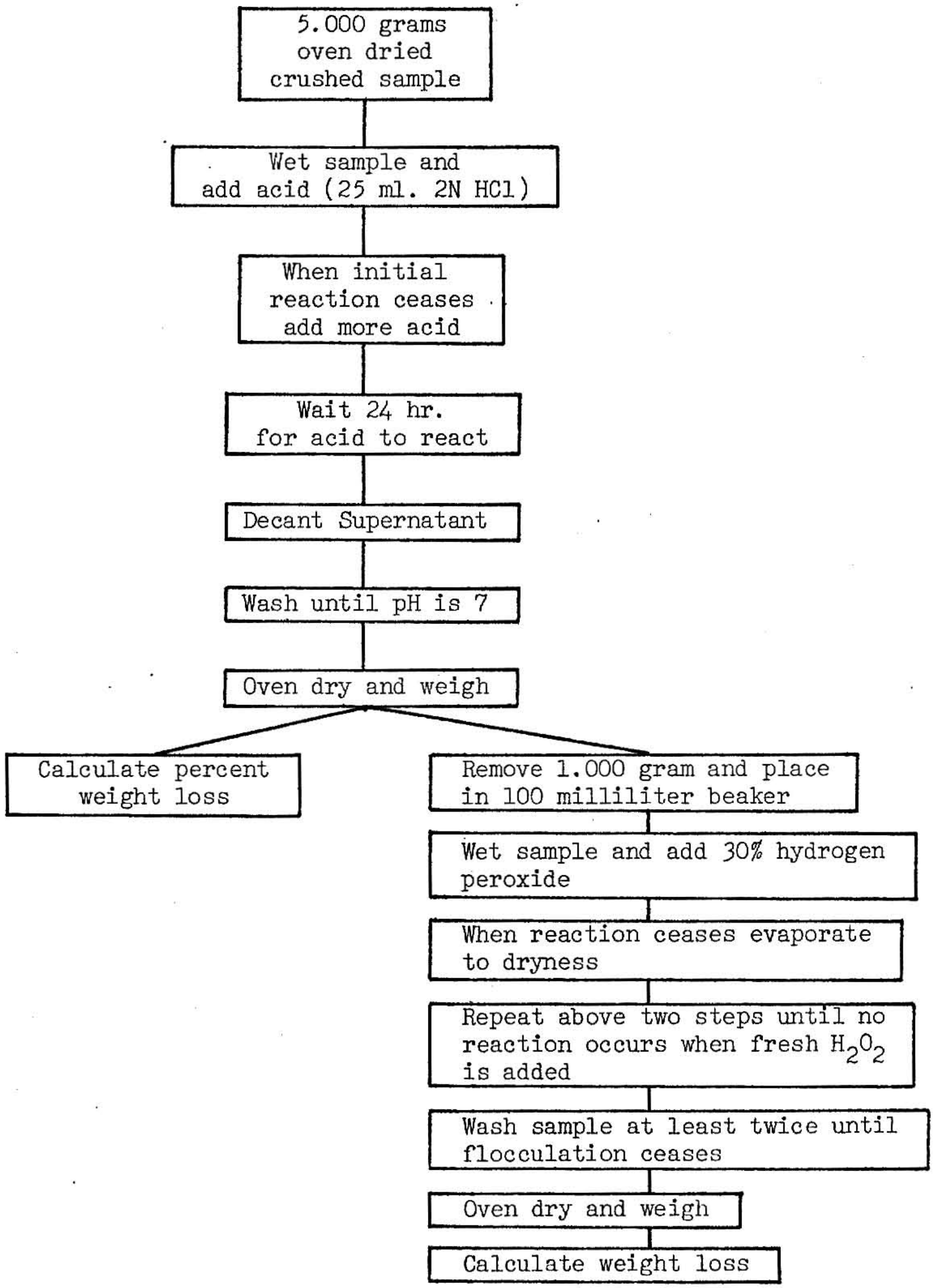
weighed to the nearest 0.001 grams, placed in vials, and covered with distilled water to decrease the violence of reaction when acid was added. Twenty-five milliliters of 2 normal hydrochloric acid was added; when the reaction ceased, usually in 15 to 20 minutes, more acid was added to insure that all soluble carbonate was removed. After 24 hours the supernatant was decanted and the residue washed (5 to 7 times) until the pH of the supernatant reached 6.5-7.0. Residues were dried, weighed to the nearest 0.001 gram, and weight loss calculated to the nearest 0.1 percent.

Because most samples were medium light gray (N6) to dark gray (N3) it was desirable to determine the amount of organic carbon. One gram of each sample of the insoluble residue was weighed to the nearest 0.001 gram, placed in a 100 milliliter beaker, covered with distilled water, and 30 percent hydrogen peroxide added. Hydrogen peroxide was added slowly in approximately 10 milliliter increments allowing the reaction to diminish before fresh hydrogen peroxide was added. To speed the reaction the beakers were placed in a drying oven at a temperature of 80°C which removed excess water created by the reaction and increased the reaction rate. When the samples were evaporated to dryness, more hydrogen peroxide was added and the process repeated until no reaction occurred when hydrogen peroxide was added. Samples were then washed with distilled water until the pH was 6.5 to 7.0. Water was removed by oven drying and percent weight loss calculated. This method is very time consuming and expensive because of the slow rate of reaction and large quantities of hydrogen peroxide required.

Grain Size Analysis.--Size and relative amounts of detrital grains are important to this study for two reasons: 1) the feeding and/or respiratory organs of some benthic marine animals are clogged by large quantities of small grains and 2) differences in size and quantities of grains might reflect the

Figure 5

Flow Diagram of Insoluble Residue Analysis



amount of energy at a particular locality.

The grain size scale used in this study is Twiss' modification of Wentworth's size class (Jeppesen, 1972, Table 1, p. 14). Several methods for analyzing grain size of mudstones are available (Royse, 1970, p. 21). Most of these involve the settling velocity of particles in a fluid medium and pipette analysis proved to be the most convenient. The principle behind this analysis is that all particles of a given size and shape settle at a constant rate in a liquid of a certain density with smaller particles settling slower than larger ones. Stoke's Law is based on this principle and assumes that all grains are spheres which they are not. Wadell (1936) more realistically assumed grains to range in shape from spheres to discs. Both values were calculated so that the relationship between these two methods could be evaluated.

Removal of carbonates is necessary for accurate analysis of grain size (Royse, 1970). Because strong acids dissolve some clay minerals 0.1 N acetic acid was used to remove the carbonate fraction. The procedure is as follows: 1) crush 60 gram sample into pea size or smaller pieces and place in wide mouth gallon jars, 2) cover with 0.1 N acetic acid for 24 hours, 3) siphon off excess liquid being careful not to remove any sediment, 4) repeat steps 2 and 3 until there is no reaction when fresh acid is added, 5) leave this acid (step 4) on sample for 24 hours to insure that all carbonates are removed, 6) wash sample by siphoning off excess liquid and filling jar with distilled water, 7) repeat step 6 until pH is between 6.5 and 7.0, 8) divide sample into 2 or 3 aliquots, and 9) wash sample two more times by centrifuging and decanting. Procedure outlined by Jeppesen (1972) was followed for the remainder of the analysis except as follows: 1) preweighed beakers were weighed five times to the nearest 0.0001 gram, 2) an average of these values computed and rounded to the nearest 0.0001 gram, 3) beakers with sediment were weighed to the nearest 0.0001 gram and step 2 followed, and 4) the greater than 62 micron fraction was not wet sieved into separate Ø (phi) fractions but was lumped into the greater than 4Ø class.

Royse (1970, p. 27) suggested that organic matter be removed by adding 30 percent hydrogen peroxide to the sample. Although no flocculation was observed in dispersed samples, I treated eight samples with hydrogen peroxide to remove any organic matter. These samples were washed (step 9 above) and a pipette analysis performed.

Authigenic minerals are formed during and after diagensis and would bias any attempt to determine grain size of the original sediment. Sand and silt fractions of each sample were examined to determine if authigenic minerals were present. A visual estimate was made of pyrite, the most abundant authigenic mineral, in all sand fractions. Less than one percent of the silt fractions were pyrite.

Clay Mineral Analysis.--Laboratory procedures used in clay mineral analysis are those of Jeppesen (1972) except as follows: 1) reactive carbonate minerals were removed using 0.1N acetic acid as described above and 2) the less than one micron fraction of the insoluble residue was obtained by centrifugation and analyzed. The following treatments described by Jeppesen (1972) were used: 1) untreated, 2) ethylene glycol, 3) heat treatment 450°C, one hour, 4) heat treatment 600°C, one hour, and 5) 6 N hydrochloric acid. X-ray diffraction settings were identical to those used by Jeppesen (1972).

Untreated slides were run from 50 to 1½ degrees (two theta), ethylene glycol and heat treated slides from 30 to 1½ degrees (two theta), and 6 N hydrochloric acid treated slides from 15 to 1½ degrees (two theta).

GEOLOGIC SETTING

Structure

The area is bisected by the south plunging Nemaha Anticline with a local structural high (Zeandale Dome) in the southern part. To more accurately interpret relationships between the five localities, a structural contour map was constructed with the top of the Americus Limestone as datum (fig. 6). This provided a more accurate reflection of the structure prior to Hughes Creek Shale deposition and a more accurate placement of the five localities with respect to the Nemaha Anticline. Localities W and BR are west of the anticline, L and DC are near the axis, and P is east of the structure. Uplift, regional tilting, and differential compaction may have changed structural relationships since Hughes Creek Shale deposition.

Stratigraphy

Where studied, the Hughes Creek Shale consisted of alternating beds of calcareous mudstones and argillaceous micritic limestones (fig. 7). Mudge and Yochelson (1962) indicated that the Hughes Creek Shale is a cherty limestone and shale in Southern Kansas. The interval studied consists of two limestones separated by mudstone and corresponds to unit 2 of Mudge and Yochelson (1962). It can be correlated from Brown County where it is two limestones and a shale to Cowley County where it is a cherty limestone. The upper limestone at all localities, contained a thin layer of what appeared to be a carbonaceous shale parting in the field.

Total thickness of the Hughes Creek Shale ranged from 9.9 to 11.4 meters thickening slightly to the south and east.

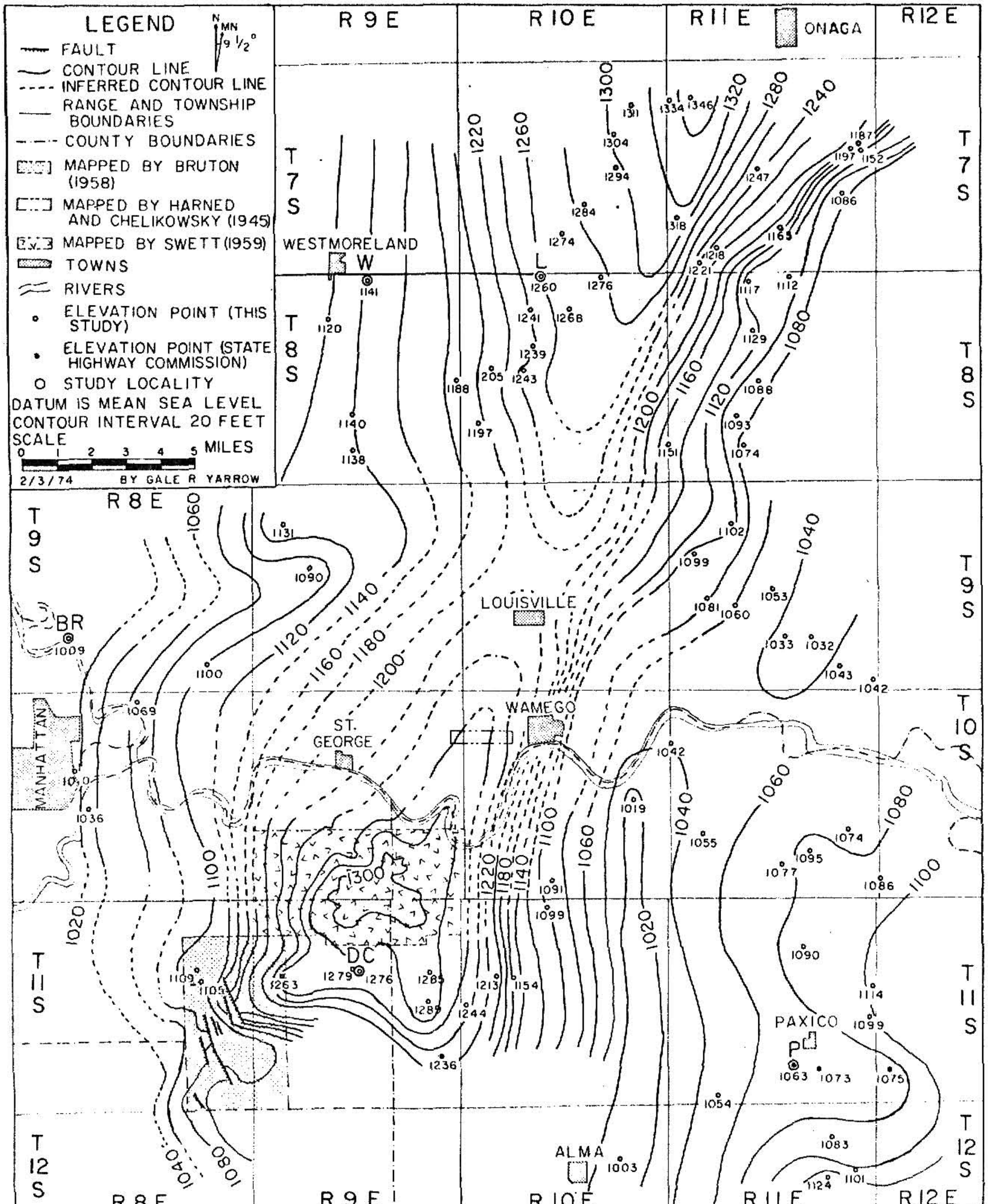


FIGURE 6 STRUCTURE CONTOURS ON TOP OF AMERICUS LIMESTONE IN POTTAWATOMIE, RILEY, AND WABAUNSEE COUNTIES, KANSAS

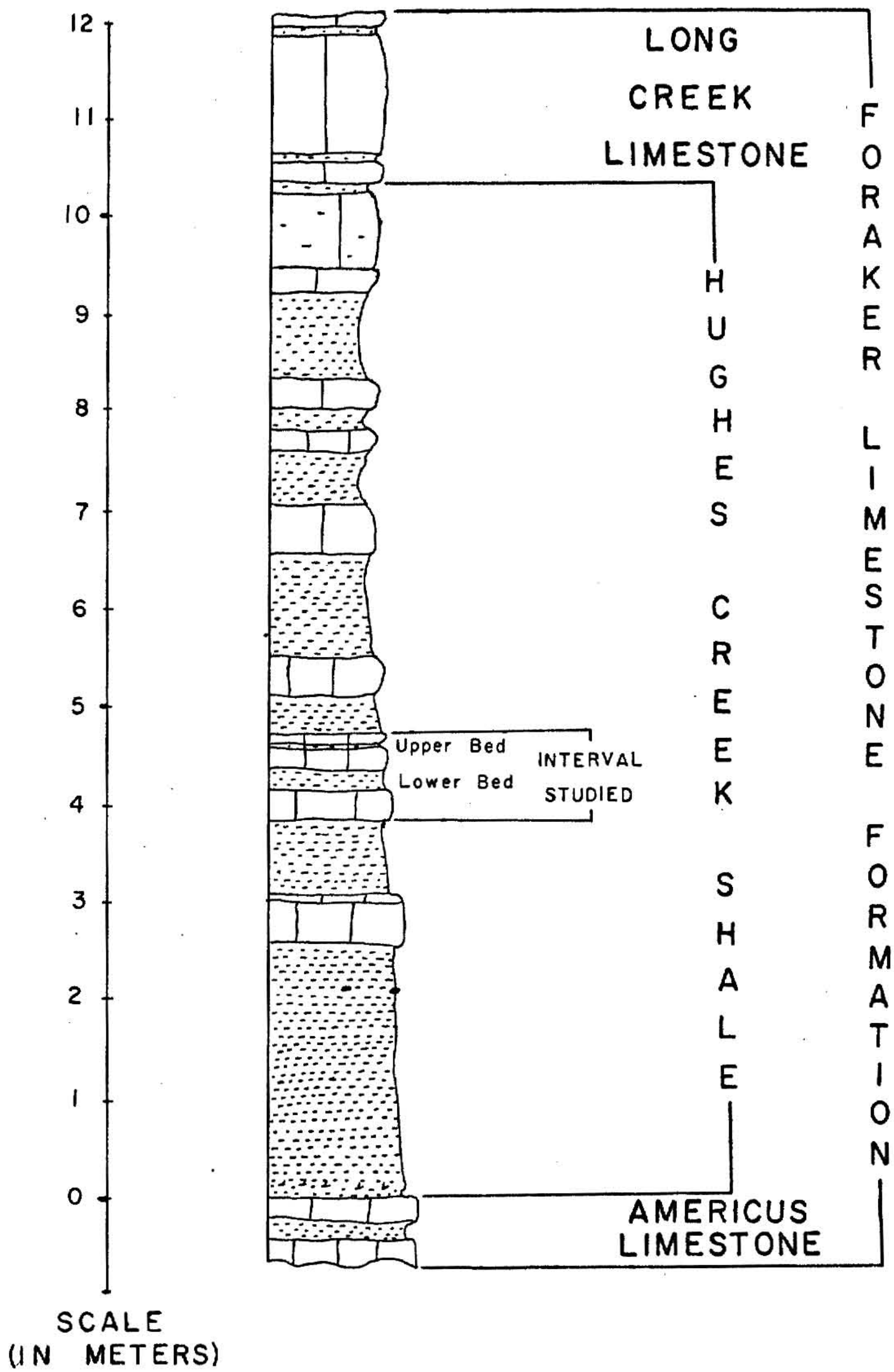


Figure 7. Typical Graphic Section of Hughes Creek Shale in Study Area.

The fossils assemblage range from a Crurthyris-Lingula dominated assemblage to a Crurthyris-productid brachiopod dominated assemblage.

INTERPRETATION OF LABORATORY DATA

Biotic Data

General Statement.--Only a small percentage of organisms (8 to 70 percent of the individuals and 10 to 55 percent of the species) living on a mud bottom have hard parts that potentially could be preserved as fossils (Johnson, 1962) giving a paleoecologist a somewhat distorted view of what lived there. Those that are preserved at a particular locality may not have lived there but may have been transported from another locality. Warme (1971) and Ekdale (1972) studying Recent marine communities indicated that live animals and shells of dead ones found at a particular locality reflect the same assemblage suggesting little effect of transportation. To determine possible transportation effects on these fossil assemblages, criteria suggested by Johnson (1960) were applied. Although quantitative data for size frequency, disassociation, fragmentation, and orientation were not calculated, impressions of these factors were obtained through careful mapping of the 41 bedding surfaces. Assemblages I encountered fit the criteria for either model I or model II assemblages as defined by Johnson (1960) and transportation is a minor factor in both of these models.

Another problem encountered involves the area studied (225 square centimeters in this case) and the area occupied by the fossil. Individual size ranges within and between species and it is obvious that three factors are involved: 1) size of area studied, 2) size of individuals or species, and 3) proportion of area occupied by different sized individuals or species in the original population or assemblage. Dennison and Hay (1967) proposed a method incorporating these three factors so that a specific area could be selected which would insure a certain probability of observing a given species. In this investigation the area was limited to 225 square centimeters and using the Dennison and Hay method if one wished to detect the prescence of 95 percent of the species which occupy one percent (2.25 $cm.^2$ of the total 225 $cm.^2$) or more of the bedding surface the sample area would be adequate only for a species which have a cross section area of 1.3 square centimeters or less. In other words the area (225 $cm.^2$) is an adequate sample for species the size of *Crurithyris* cf. *expansa* or smaller.

Data used in calculating diversity and equitability was obtained from an area of 225 square centimeters from each of 41 bedding surfaces. Unidentifiable and extensively fragmented specimens were not used in diversity calculations. Generic and specific designations were determined by comparison with published descriptions. Because two species of the same genera seldom live together (Turpaeva, 1957) each taxon was assumed to be a single species. Number of individuals (density) was assumed to be reflected by the greatest number of valves (pedicle or brachial, right or left) of a particular species. For example if 18 pedicle valves and 11 brachial valves of *Crurithyris* cf. *expansa* were present on a bedding surface this would be counted as 18 individuals. In the case of *Lingula* cf. *carbonaria*, where it is difficult to distinguish between pedicle and brachial valves, the total number of valves was divided by two to obtain the number of individuals. If this value was a fraction, the density was rounded up to the next whole number.

Diversity.--Diversity is commonly described as the number of species but in this study it indicates the relationship between numbers of species and numbers of individuals. Diversity is increased by either larger number of species and/or a more nearly equal number of individuals in each species.

Diversity values were calculated for each mapped surface (Table 2) using the Shannon-Wiener function for species diversity (Margalef, 1957 and MacAuthur and MacArthur, 1961). Lack of preservable hard parts in 45 to 90 percent of the species and 30 to 93 percent of the individuals living on mud bottom sediments (Johnson, 1962) produces some bias but it is the same for all bedding surfaces and will not affect between bedding surface comparisons. West and Twiss (1972) indicated that removal of these non-preservable soft-bodied organisms from a recent sample lowers the diversity but has little effect on equitability.

Equitability.--Another method of examining the species-individual relationship is equitability, which provides a numerical measure of species evenness expressed as:

$E=\frac{s'}{s}$ where

E= Equitability

s'= hypothetical number of species with an equal number of individuals in each species that would be needed to produce a species diversity equivalent to the observed one.

s= actual number of species observed (Lloyd and Ghelard, 1964).

Higher equitability values indicate a more nearly equal number of individuals in each species. Table 2 lists equitability values calculated for each surface mapped. Deevey (1969) indicated that equitability values greater than one indicate possible transportation of fossils after death. A more plausible explanation is that the area mapped (225 $cm.^2$) was too small resulting in a biased sample. Even though this bias exists values should be comparable because the bias is similar for all surfaces.

Autecology.--Interrelationships between a species and its environment is autecology (Raup and Stanley, 1971). It is not the purpose of this study to

Table 2

Diversity and Equitability of Fossil Assemblages
from Part of the Hughes Creek Shale

Bedding Surface Number	Diversity	Equitability
W-9b-1##	1.578	0.946
W-8-5#	2.558	1.154
W-8-4#	2.408	1.202
W-8-3#	0.595	0.578
W-8-2#	1.628	0.784
W-8-1#	1.033	0.491
L-10-3##	0.468	0.788
L-10-2##	1.222	0.947
L-10-1##	1.186	0.692
L- 8-9#	1.512	0.719
L -8-8#	2.322	1.126
L- 8-7#	1.266	0.488
L- 8-6#	1.379	0.645
L- 8-5#	2.256	1.285
L- 8-4#	1.668	1.011
L- 8-3#	2.986	1.224
L- 8-2#	2.717	0.910
L- 8-1#	2.568	1.018
BR-4b-1##	1.558	0.932
BR-3-5#	0.810	0.999
BR-3-4#	0.000	1.000
BR-3-3#	3.435	1.108
BR-3-2#	3.086	1.199
BR-3-1#	2.644	1.079
DC-7d-1	1.910	0.981
DC-7b-2##	1.541	0.613
DC-7b-1##	0.605	0.582
DC-6-6#	1.149	0.897
DC-6-5#	2.591	1.382
DC-6-4#	3.332	1.106
DC-6-3#	3.488	1.151
DC-6-2#	2.731	1.022
DC-6-1#	2.256	1.285
P-7b-3##	0.658	0.604
P-7b-2##	1.721	1.058
P-7b-1##	0.880	0.428
P-6-6#	0.923	0.743
P-6-5#	1.003	1.196
P-6-4#	1.797	1.126
P-6-3#	3.166	1.157
P-6-2#	3.329	1.305
P-6-1#	1.874	0.955
P-5b-1	2.003	1.056

upper bed # lower bed

examine these relationships in detail but to consider trophic level, mode of life, and feeding behavior as aids in understanding the structure and hopefully, the dynamics of the fossil assemblages.

Whittaker (1970) used five trophic levels to define the food chain: producer, herbivore or primary consumer, first carnivore, second carnivore, and tertiary carnivore. The lowest level, or producer, produces food for all other levels by photosynthesis and in marine waters today the most abundant producers are diatoms and other algae.

Some of the energy produced by plants is utilized by primary consumers, which are eaten by first carnivores and in turn are eaten by second carnivores and so forth. Seldom are food chains this simple because secondary and tertiary carnivores can eat herbivores and lower level carnivores resulting in a complex pattern of energy flow.

Mode of life or the relationship between an organism and its substrate or medium might suggest environmental factors that affect that organism. Mode of life categories are similar to those defined by Scott (1973) and are: 1) epifaunal (living on the substrate), 2) infaunal (living within the substrate), 3) quasi-infaunal (simulating an infaunal habit like some productids), 4) semi-infaunal (half in and half out of the substrate like *Pteronites*, *Pinna*, etc.), and 5) nektonic (swimming in water above the substrate).

If all primary consumers were competing for the same resource (food) in the same way then according to the law of competitive exclusion, one species should become dominant by out competing all other species. If the species were separated into different feeding behaviors (Turpaeva, 1957) they would no longer be in direct competition with each other. Walker (1972, p. 83) related Turpaeva's trophic groups (feeding behavior) to United States' terminology and Walker's terms applicable to this study are defined in Table 3.

Table 3

Definitions of Feeding Behavior

Type feeding behavior	Definition
Low level suspension	Feeds within 3 millimeters of the sediment-water interface.
High level suspension	Feeds higher than 3 millimeters above sediment-water interface.
Collectors	Epifaunal deposit and particulate feeders.

The basis for separating primary consumers into high and low level suspension feeders was based on observed behavior and the three millimeter line used by Turpaeva (1957) is based on modern benthic invertebrate assemblages living in the Barents Sea. Assignment of fossils to specific feeding behaviors (strategies) is difficult because the life orientation and functional morphology of many organisms is unknown. Feeding behvaior is inferred from the functional morphology of fossil skeletons and by comparison with morphologically similar or taxanomically related forms. Trophic level, mode of life, and feeding behavior of the taxa encountered in this study are listed in Table 4.

Foraminiferids.--Fusulinids were the only foraminiferids observed on the mapped surfaces. Other foraminiferids were identified in washed residues but were too small to be observed on bedding surfaces. Ross (1961 & 1969) indicated that fusulinids are benthic and probably lived on the substrate. West (1970, p. 80) indicates that foraminiferids feed on particulate matter, therefore, by definition they are collectors. Some of this particulate matter is produced by producers classifying foraminiferids as primary consumers.

Table 4

Autecology of Fossils

Trophic Level	Modes of Life	Feeding Behavior
P-Primary=herbivore S-Secondary=first carnivore T-Tertiary-second carnivore	I-Infaunal E-Epifaunal Q-Quasi-infaunal S-Semi-infaunal N-Nektonic	LS-Low level suspension HS-High level suspension C-Collector Carn-Carnivore

Taxon	Trophic level	Mode of life	Feeding behavior
Protozoa			
Foraminifera			
Fusulinids	P	E	C
Ectoprocts			
ramose type 1	P	E	HS
2	P	E	HS
3	P	E	HS
4	P	E	HS
fenestrate type 1	P	E	HS
2	P	E	HS
Brachiopoda			
Inarticulata			
Lingula cf. carbonaria	P	I	LS
Orbiculoidea cf. missouriensis	P	E	LS
Petrocrania cf. modesta	P	E	LS
Acanthocrania sp.	P	E	LS
Articulata			
Wellerella cf. osagensis	P	E	HS
Crurithyris cf. expansa	P	E	HS
Composita cf. subtilita	P	E	HS
Derbyia cf. crassa	P	E	HS
Meekella cf. striatocostata	P	E	HS
Neochonetes cf. granulifer	P	E	HS
Lissochonetes cf. geinitzianus	P	E	HS
Reticulatia cf. huecoensis	P	Q	LS
Juresania cf. nebrascensis	P	Q	LS
Hystriculina cf. histricula	P	Q	LS
Ritaria cf. lasallensis	P	Q	LS
Linoproductus cf. magnispinus	P	Q	LS
Cancrinella cf. boonensis	P	Q	LS
Rhipidomella cf. carbonaria	P	E	HS
Hustedia cf. mormoni	P	E	HS
Punctospirifer cf. kentuckensis	P	E	HS
Neospirifer cf. dunbari	P	E	HS

Table 4 cont.

Taxon	Trophic level	Mode of life	Feeding behavior
Mollusca			
Bivalvia			
Volsellina? sp.	P	S	HS
Pteronites cf. peracuta	P	S	LS
Pinna? sp.	P	S	LS
Myalina sp.	P	E	HS
Septimyalina sp.	P	E	HS
Schizodus sp.	P	I	LS
Aviculopecten cf. arctisulcatus	P	E	HS
Wilkingia cf. terminale	P	S	LS
Echinodermata			
crinoid debris	P	E	HS
echinoid debris	S	E	Carn.
Arthropoda			
trilobite debris	P	E-I	C
ostracodes	P	N-E-I	C
Vertebrata			
fish debris	T	N	Carn.

Ectoprocts.--Two major growth forms of ectoprocts were observed, ramose and fenestrate. Different growth forms suggest different genera and/or species but detailed taxonomic description was beyond the scope of this study and different growth forms were assigned numbers (Plate I). Some fenestrate types were very delicate and occurred as large pieces indicating a low energy environment. If isolated fragments on any one surface appeared to belong to the same colony they were counted as one individual. Some fragments (ramose type 3) were broken after deposition and it was possible to reconstruct a branching colony with a maximum lateral dimension of 15 centimeters and a maximum vertical dimension of 7 centimeters (Plate II, fig. 3). Ectoprocts provided a solid substrate for other ectoprocts, spirobid worms, and Petrocrania during life and/or after death (Plate II, fig. 3a). Many ramose types were attached to brachiopod and bivalve shells apparently requiring a solid substrate for attachment. Ectoproct colonies were part of the attached epifauna and unable to pursue food except by creating water movements with their lophophore. Some writers (Turpaeva, 1957) consider ectoprocts awaiters but because most of my specimens were greater than three millimeters long (high) I considered them high level suspension feeders. Trophic level is primary (Scott, 1973).

Brachiopods.--Brachiopoda, the most diverse phyla encountered, is represented by inarticulates as well as articulates. Lingula, classified as an infaunal low level suspension feeder by Walker (1972) is given another mode of life by Zangerl and Richardson (1963). They suggest that Lingula was a pseudoplanktonic sessile benthos because it occurred in fine-bedded pyritic humulite which was interpreted as representing a floating mat of vegetation. Zangerl and Richardson (1964, p. 194) said:

> Modern lingulas are attached to the bottom mud. All our evidence concerning bottom conditions and character of mud at Mecca and Logan Quarries renders a similar interpretation all but impossible here.

Although few Lingula were observed in "normal" life position (inclined to bedding) I feel that during depositon of this interval Lingula were infaunal because they are associated with some burrows and bottom-dwelling bivalves.

Rudwick (1970) indicated that some productid brachiopods had a "quasi-infaunal" mode of life with supporting spines that allowed them to live in a soft substrate for protection with only the anterior commissure above the substrate for food gathering (Plate II, fig. 2 & 2a). All other brachiopods encountered are considered epifaunal. Feeding behavior of brachiopods depends on how high above the sediment-water interface the inhalent current originated. This must be inferred from hard part morphology and habits of living brachiopods. Although Orbiculoidea, Petrocrania, and Acanthocrania were classified as low level suspension feeders because of hard part morphology they may have been high level suspension feeders because of attachment position on other organisms. All brachiopods are classed as primary consumers (Scott 1973).

Bivalves.--The only molluscs observed on bedding surfaces were bivalves. Mode of life and feeding behavior of bivalves are those proposed by Stanley (1968 & 1970) and Pearce (1973) for the genera encountered and are considered primary consumers (Scott 1973).

Echinoderms.--Echinoderms are represented by crinoid and echinoid debris. Because both organisms may be epifaunal and are easily disarticulated, it is not unusual to find only fragments of the whole animal. Attached as well as unattached (floating) crinoids are known in the geologic record. I was not able to distinguish between the two forms but both would have had the same feeding behavior (high level suspension feeder). Crinoids are considered as members of the primary trophic level (Scott 1973). Echinoids can live on or within the substrate and can eat detritus as well as live prey. In this study echinoids are considered as epifaunal carnivores following West (1970, p. 84).

Arthropods.--Ostracodes and trilobites are arthropods and were observed on only one surface. Both ostracodes and trilobites were represented in washed residues but ostracodes were more abundant. Inferred trilobite behavior permits either epifaunal or infaunal mode of life and ostracodes have been observed to behave as infaunal, epifaunal, and nektonic. Walker (1972) considered both as collectors.

Chordates.--Dermal plates and teeth of fish were observed in washed residues and on a single bedding surface. Fish are nektonic and are considered second carnivores.

Trace fossils.--Horizontal and vertical mottling (Plate II, fig. 1) are interpreted as results of bioturbation which is more apparent in the argillaceous micritic limestone (upper bed) than the mudstone (lower bed). This may indicate more reworking and/or a near shore environment (Gebelein, 1971, p. 339-340).

Statistical Analysis.--To compare fossil assemblages between localities and within beds at one locality a Q-mode cluster analysis using the Dice correlation coefficient was employed. Q-mode cluster analysis permits the quantification of similarity between two or more localities, beds, species, etc.

For this technique the taxonomic categories (Table 4) were used as one side of a matrix with localities, or beds, as the other (fig. 8). In this way every locality was compared with every other locality (i.e. L-W, L-BR, L-DC, L-P, W-BR, W-DC, W-P, BR-DC, BR-P, DC-P) in terms of presence and/or absence of total taxa.

The correlation coefficient of Dice (1945) as given by West (1970) is:

Taxonomic Entities	Localities				
	L	W	BR	DC	P
Fusulinids	X			X	X
Ramose type I	X		X	X	
II			X	X	
III		X	X	X	X
IV			X	X	X
Fenestrate type I			X	X	X
II		X	X	X	X
Lingula	X	X	X	X	X
Orbiculoidea	X	X	X		X
Petrocrania	X			X	
Acanthocrania?				X	
Wellerella			X	X	
Crurithyris	X	X	X	X	X
Composita	X			X	
Derbyia	X	X	X	X	X
Meekella				X	
Neochonetes	X	X	X	X	X
Lissochonetes	X				
Reticulatia	X	X	X	X	X
Juresania	X	X		X	
Hystriculia	X	X	X		X
Ritaria			X		X
Linoproductus		X	X	X	X
Cancrinella	X		X		X
Rhipidomella	X	X			X
Hustedia	X				
Punctospirifer				X	
Neospirifer	X	X	X	X	X
Volsellina?		X		X	X
Pteronites				X	
Pinna?	X		X	X	
Myalina	X	X	X	X	X
Septimyalina				X	
Schizodus	X			X	
Aviculopecten	X	X	X	X	X
Wilkingia	X	X		X	
Crinoid debris	X		X	X	X
Echinoid debris	X		X		
Trilobite debris	X				
Ostracodes					X
Fish debris	X		X		X

X=Presence of Taxon at this Locality

Figure 8. Data Matrix of Taxonomic Entities and Localities from Part of the Hughes Creek Shale.

$$S = \frac{2N_{jk}}{2N_{jk}+u} \quad \text{where}$$

S= coefficient

N_{jk} = number of matches

u= number of mismatches.

Positive matches are weighted twice as heavy as mismatches which is reasonable because of the concept of consistent and recurrent association of species in marine ecology (West, 1970, p. 34). Values for the coefficient range from 0.0 - 1.0 with values approaching 1.0 indicating greater similarity and vice versa.

Values obtained from this coefficient were placed in a symmetrical matrix and a cluster analysis performed by using the weighted pair group method with simple arithmetic averages (West, 1970, p. 34). Correlation coefficients with the highest values in two or more locations were combined into one value and the matrix reduced accordingly until a 2 x 2 matrix remained or the relationship between the localities was zero. These relationships are commonly illustrated by a dendrogram.

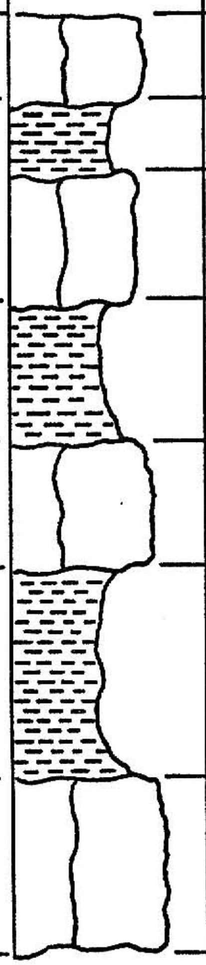
Petrologic Data

General Statement.--Petrology is defined by Howell *et al.* (1962, p. 377) as follows:

> A general term for the study by all available methods of the natural history of rocks, including their origins, present conditions, alterations and decay.

In this study all available means includes weight percent of insoluble residue, weight loss per gram of organic carbon, grain size analysis, and clay mineral analysis. It is important to realize that a rock is the end product of everything that has happened to it prior to collecting including sedimentation, diagenesis, and exposure to natural forces at the earth's surface. It is nearly impossible to determine exactly when, during the rock's history, certain events took place. This study partly attempted to identify sediment parameters before diagenesis and those occurring after weathering. The effect of weathering was minimized by selecting the "freshest" exposures available. Samples for petrologic study were selected as follows (fig. 9): 1) if the bed is less than eight centimeters thick, a single composite sample was taken, 2) if the bed is between eight and 16 centimeters thick, two composite samples were taken (one from the lower half and one from the upper half), and 3) if the bed is greater than 16 centimeters thick, three composite samples were taken (top, middle, and bottom). Clay mineral samples were composited from each bed. Figure 9 illustrates sampling intervals used.

Insoluble Residues.--To obtain an estimate of terrigenous detritus, it was necessary to remove all reactive carbonates. Some lithologic units termed mudstones in the field are actually limestones based on insoluble percent (i. e. the insolubles were less than 50 percent). Insoluble weight percent indicate carbonates that may have entered the rock in one or more of the following ways: 1) it may have been part of the original sediment, 2) it may have been added or leeched by interstitial water during diagenesis, or 3) it may have been leeched or precipitated by weathering of the rock after being exposed to weathering. Table 5 lists the percent insolubles for each sample analyzed. Insoluble percent in both beds (lower and upper) at locality L are similar and they are also more weathered than beds at other localities. A possible explanation could be that carbonate was leeched from the overlying limestones by weathering and precipitated in the mudstones equalizing the insoluble percent within the interval. In the lower bed (W-8, L-8, BR-3, DC-6,



Thickness	Idealized Graphic Section at Locality X	Bed No.	Samples for Grain Size and Insoluble Residue Analysis		Samples for Clay Mineral Analysis	
			Sample No.	Interval	Sample No.	Interval
		X - 7				
1-8 cm.		X - 6	X - 6 - 1		X - 6	
		X - 5				
8-16 cm.		X - 4	X - 4 - 2 X - 4 - 1		X - 4	
		X - 3				
>16 cm.		X - 2	X - 2 - 3 X - 2 - 2 X - 2 - 1		X - 2	
		X - 1				

Figure 9. Petrographic Sampling Procedures

Table 5

Insoluble Residues of Part of the Hughes Creek Shale

	Insoluble Residue Weight Percent	Organic Carbon Weight Loss per Gram of Insoluble Residue
W-9b##	36.3*	0.028
W-8-3#	72.5	0.024
W-8-2#	85.7*	0.020
W-8-1#	74.2	0.026
L-10-2##	45.3	0.040
L-10-1##	45.8	0.044
L-8-3#	42.4	0.029
L-8-2#	61.7	0.041
L-8-1#	56.8	0.029
BR-4b##	38.2	0.027
BR-3-2#	78.5	0.016
BR-3-1#	75.8	0.011
DC-7d	44.8	0.027
DC-7b##	47.9	0.061
DC-6-3#	74.1	0.016
DC-6-2#	79.6	0.013
DC-6-1#	72.6	0.021
P-7b-2##	43.9	0.070
P-7b-1##	38.8	0.043
P-6-3#	61.4	0.020
P-6-2#	68.8	0.024
P-6-1#	65.0	0.028
P-5b	23.6	0.013

* average of two values

\# lower bed
\## upper bed

P-6) insolubles were highest in the center of the bed decreasing in both directions towards limestones. Two explanations are possible: 1) a predominantly carbonate depositional environment existed and the amount of terrigenous detritus gradually increased reaching a maximum and then gradually decreased upward or 2) interstitial water has redistributed soluble carbonates obscuring sharp contacts. I prefer the former explanation because 1) some sharp contacts were observed in the field and 2) the entire Foraker Limestone is calcareous. Table 6 lists results of two replications to check reproducibility and the largest difference is 2.0 percent.

Table 6

Replication of Insoluble Residue Data from Part of the Hughes Creek Shale

Sample	Insoluble wt. %	
	Run 1	Run 2
W-9b	37.3	35.3
W-8-2	85.2	86.1

Organic carbon is an indicator of reducing conditions during deposition. If bottom waters were well oxygenated, carbon would be oxidized before diagenesis. Table 5 lists values calculated for weight loss when organic carbon was removed.

Field observations revealed that the upper bed was darker than the lower bed at all localities and a t-test of weight loss after removal of organic carbon (Table 7) indicates a significant difference between the two (i. e. the upper bed lost more weight than the lower bed). If presence of organic carbon indicates an oxygen deficient environment, then conditions for benthic invertebrates were less favorable in the upper bed than in the lower bed.

Table 7

Statistical Comparison of Organic Carbon between Beds of the Hughes Creek Shale

Bed	ΣX	ΣX^2	$\bar{X}$	n	t-test
Upper	0.313	0.015519	0.0447	7	
Lower	0.318	0.008018	0.0227	14	4.30**

** significant difference at 0.05 level

Grain Size.--Cumulative weights obtained from pipette analysis were used to calculate cumulative weight percentages and individual class weights (Appendix III). Cumulative weight was plotted against grain size (in Ø units) on arithmetic-normal probability graph paper and graphic median grain size determined. All cumulative curve plots were open ended and some did not reach the 84th percentile (part of the sample was still in suspension after 64 hours and 28 minutes at a depth of 5 cm.). In one case as much as 45 percent of the sediment was still in suspension after 64 hours and 28 minutes at 5 centimeters. With curves that do not reach the 84th percentile median grain size is the only graphic statistic available using the criteria of Folk and Ward (1957). Folk and Ward (1957) indicated that the open end should be completed by drawing the curve to 100 percent at 14Ø. Royse (1970) suggested that it would be better to use only the known part of the curve. Samples of sediment less than 12 and 13Ø were taken from 13 samples (out of a total of 32) to test the practicality of Folk and Ward's suggestion. No inflection of the cumulative curve was noted indicating that quantities of these size classes did not decrease as predicted, therefore, I followed Royse's suggestion and used only the known part of the curve.

One possible explanation for the large quantity of clay remaining may be that the dispersant, sodium hexametaphosphate (calgon), dissolved it. More clay would be dissolved the longer the sample is in contact with the dispersant. If this is true, weights of the smaller size fractions (less than 10 or 11Ø) will be larger than actual values. This explanation could be tested by dispersing a sample, splitting it into two aliquots, placing one in a hydrometer jar to settle and centrifuge the other to separate size fractions. Because centrifugation is faster, the sample is not in contact with the dispersant as long. If weights of the fine fraction (greater than 10Ø) in the hydrometer jar sample are larger than corresponding weights determined by centrifugation then the hypothesis is supported.

It was not the purpose of this study to test the pipette method but reproducibility should be checked in any scientific study. One sample was divided into two subsamples so that reproducibility could be checked (Table 8). Royse (1970) indicated that with careful analysis reproducibility of median grain diameter should be within 0.2Ø. The difference between median grain size shown in Table 8 is 0.19Ø.

Stoke's law for settling particles assumes that all particles are spheres while Wadell's modification assumes particle shape between a sphere and a disc (Royse, 1970). Withdrawal times used were calculated using Stoke's law but values were transformed to Wadell's modification by recalculating size fractions as described by Folk (1968, p. 40) and redrawing cumulative curves. This modification decreases median grain size about 0.3Ø units and values for both are recorded in Table 9.

Median grain size values appeared smaller in the upper bed than in the lower bed. A t-test of median grain size indicates a significant difference between these beds (Table 9).

Table 8

Result of Duplicate Pipette Analysis of Part of the Hughes Creek Shale

Grain Size Distribution using Stoke's law
(Cumulative Percent)
Sample P-6-2

Class Interval (Ø units)	Run 1	Run 2
4.0	0.11	0.18
4.0-4.9	0.58	0.91
5.0-5.9	8.17	8.18
6.0-6.9	28.65	29.15
7.0-7.9	43.19	44.22
8.0-8.9	52.51	54.86
9.0-9.9	61.48	63.26
10.0-10.9	68.17	68.93
11.0-11.9	76.83	79.43
12.0-12.9	86.40	87.96
Median	8.23Ø	8.42Ø

Table 9

Grain Size and Statistical Difference Between Beds of the Hughes Creek Shale

Sample Number	Stoke's Law Median	Wadell's Modification to Stoke's Law	Coarsest 1 %
	(Ø units)	(Ø units)	(Ø units)
W-9b##	9.62	9.39	4.83
W-8-3#	8.48	8.15	4.70
W-8-2#	8.67	8.34	5.02
W-8-1#	9.02	8.75	5.03
L-10-2##	9.85	9.68	4.68
L-10-1##	9.75	9.48	4.30
L-8-3#	8.67	8.30	4.60
L-8-2#	8.83	8.56	4.70
L-8-1#	8.97	8.63	4.57
BR-4b##	9.31	9.01	4.20
BR-3-2#	9.32	9.18	4.76
BR-3-1#	9.13	8.82	4.75
DC-7d-1	9.59	9.28	3.88
DC-7b-1##	9.38	9.12	4.52
DC-6-3#	8.23	7.93	4.37
DC-6-2#	9.13	8.82	4.83
DC-6-1#	9.07	8.80	5.20
P-7b-2##	8.78	8.50	4.45
P-7b-1##	9.56	9.22	4.42
P-6-3#	8.45	8.11	4.67
P-6-2#	8.72	8.23	4.76
P-6-1#	9.10	8.96	4.86
P-5b	8.50	8.18	4.71

Bed	ΣX	ΣX^2	$\bar{X}$	n	t-test
##upper bed	64.40	593.3578	9.20	7	3.822*
# lower bed	119.58	1023.1498	8.54	14	

*significant at 0.05 level

Because Royse (1970) indicated that organic carbon might interfere with pipette analysis eight subsamples were treated with hydrogen peroxide to remove organic carbon before the analysis was performed. Median grain size from these analyses and a paired t-test between treated and untreated samples are given in Table 10. The difference is significant at the 0.05 level indicating that removal of organic carbon decreases grain size. A linear regression (using a Monroe 1775 calculator) was calculated to show the relationship between amount of organic carbon and changes in median grain size (fig. 10). The correlation coefficient is -0.8911 which is significant at 0.01 level (Snedecor and Cochran, 1971, p. 557, Table A 11).

Using figure 10, change in grain size can be calculated for removal of organic carbon if percent of organic carbon is known. Because change in grain size is small and small quantities of organic carbon are present, these changes were ignored.

All methods of grain size analysis indicate grain size of the rock not of the original sediment. Authigenic minerals are formed after deposition and are not part of the original sediment. All sand and silt size fractions were examined using a binocular microscope and grains observed in these size fractions were quartz, chert, and pyrite. With the time available, it was not possible to distinguish between authigenic chert and detrital chert so all chert was considered detrital. Folk (1968, p. 97) indicated that pyrite is nearly always authigenic so to obtain original grain size pyrite should be removed from the greater than 4Ø size class. Visual estimates were made of pyrite in the greater than 4Ø class for each sample (Table 11). Because the specific gravity (Hurlbut, 1966, p. 606) of pyrite (5.02) is nearly twice that of quartz (2.65) it is possible to convert visual estimates of pyrite to weight percent by the following approximate relationship. Weight percent pyrite = (2X) times (visual percent

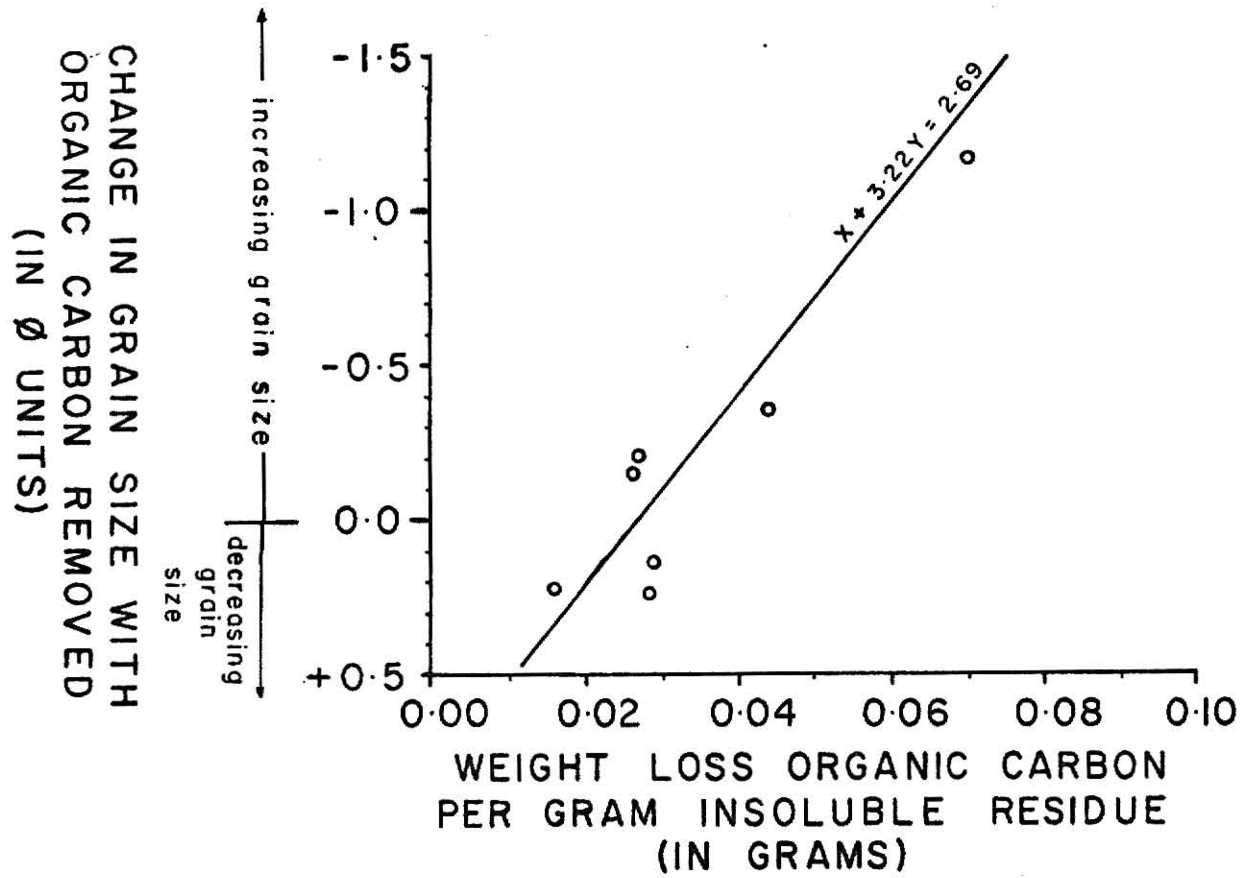


Figure 10. Relationship Between Median Grain Size and Organic Carbon from Part of the Hughes Creek Shale.

Table 10

Effects of Organic Carbon on Median Grain Size in Part of the Hughes Creek Shale

Sample Number	Median without H_2O_2 Treatment	Median with H_2O_2 Treatment	Change in Median Grain Size (in Ø Units) (D)	Wt. % Organic Carbon
	(Ø units)	(Ø units)		
W-8-1	8.75	8.90	-0.15	2.6
L-10-1	9.48	9.83	-0.35	4.4
L-8-1	8.63	8.49	0.14	2.9
BR-4b	9.01	9.22	-0.21	2.7
BR-3-2	9.18	8.95	0.23	1.6
DC-7d	9.28	9.63	-0.35	2.7
P-7b-2	8.50	9.67	-1.17	7.0
P-6-1	8.96	8.72	0.24	2.8
Mean			-0.202	

$$t = \frac{\text{Mean of D}}{\text{Standard Deviation of D}} = \frac{0.202}{0.027} = 7.481^*$$

* significant difference at 0.05 level

pyrite) where X = a factor to convert visual percent to weight percent (Table 12). Using this factor cumulative curves were redrawn and the coarest one percentile recorded in Table 9.

Passega (1957) plotted the coarest one percent grain size against median grain size (CM diagram) and concluded that different depositional environments occupied separate areas in this binary diagram. Plotting these two parameters (fig. 11) all values are clustered near the area of quiet water deposition according to Passega (1957). Although both beds plot in the same general area of the CM diagram the points are not interspersed. This could be due to the smaller median grain size of the upper bed and/or more energy available for transportation.

Clay Minerals.--Clay minerals were identified and quantified by Dr. Page C. Twiss. Clay minerals and relative quantities in each sample are listed in Table 13. Illite is the dominant clay mineral in all samples with chlorite or vermiculite being the second most abundant. Random interlayered illite-vermiculite occurred in some samples. Vermiculite could be a product of weathered chlorite because it only occurs at well weathered localities (L and BR). Weathering at localities L and BR must have been deep because samples were taken from depths of two to three feet below the outcrop face. Random interlayered clays, illite-vermiculite, might indicate an early stage of weathering because it ranks third in abundance and only occurs in some of the beds at localities D and P. Locality W, the "freshest" locality contained only illite and chlorite.

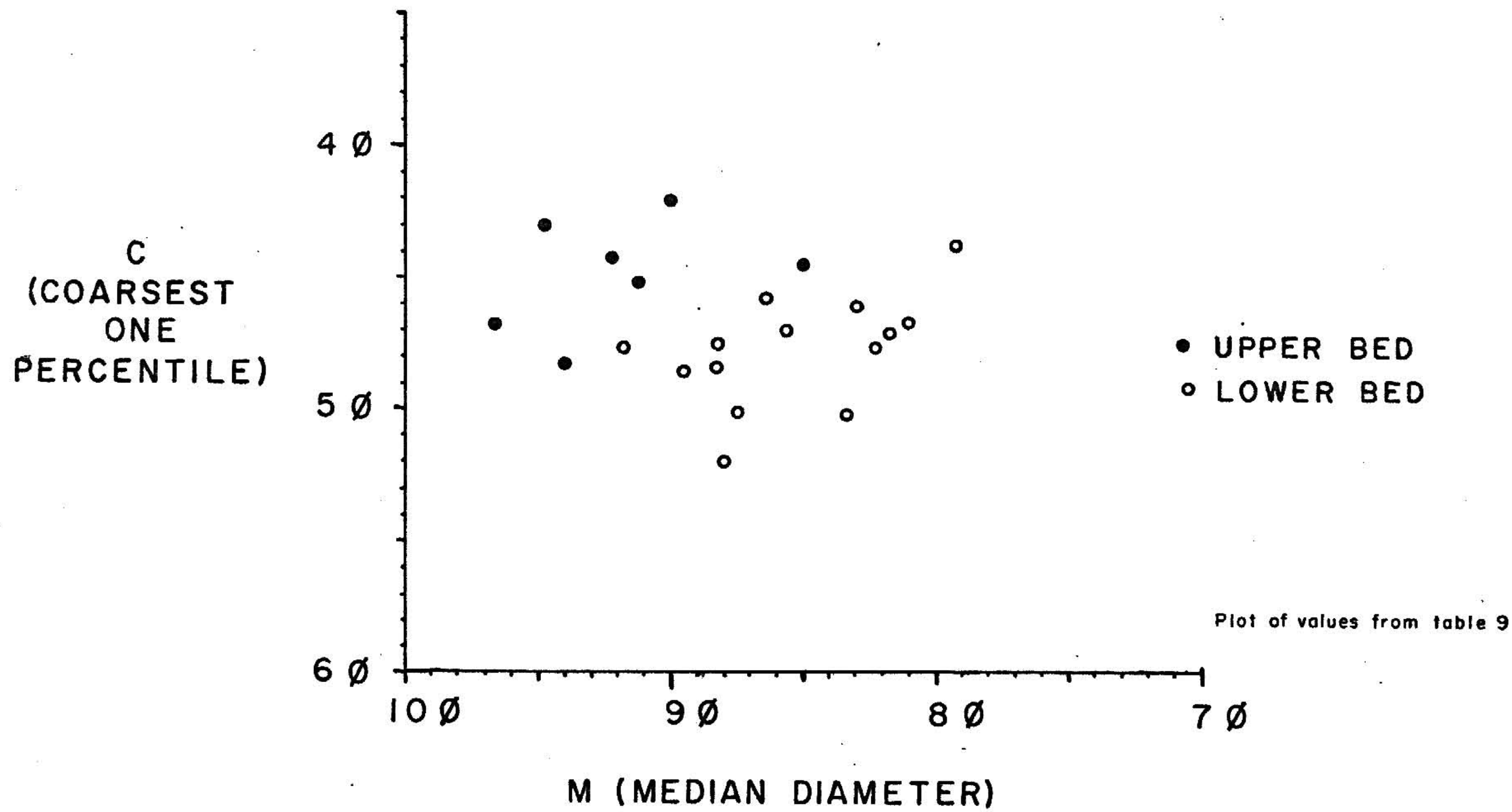


Figure 11. CM Diagram from Part of the Hughes Creek Shale.

Table 11

Authigenic Minerals from Part of the Hughes Creek Shale

Sample	Visual Estimate % Pyrite	Estimate Weight % Pyrite
W-9##	10	18
W-8-3#	20	33
W-8-2#	40	57
W-8-1#	90	95
L-10-2##	70	82
L-10-1##	60	75
L- 8-3#	70	82
L- 8-2#	95	97
L- 8-1#	80	88
BR-4b##	10	18
BR-3-2#	30	46
BR-3-1#	25	40
DC-7d	1	2
DC-7b##	70	82
DC-6-3#	10	18
DC-6-2#	15	26
DC-6-1#	25	40
P-7b-2##	15	26
P-7b-1##	25	40
P-6-3 #	10	18
P-6-2 #	60	75
P-6-1 #	60	75
P-5b	20	33

upper bed
lower bed

Table 12

Derivation of Weight Percent Conversion Factor

A = Visual percent pyrite
B = Visual percent other insolubles (SiO_2 in this case)

1) A+B = 100 visual percent

2) 100 visual percent - A = B

3) 2AX+BX = 100 wt. percent — Because the specific gravity of pyrite is nearly twice that of SiO_2 and where X = factor for converting visual percent to weight percent.

4) Substituting 2 in 3, 2AX+X (100 visual percent - A) = 100 wt. percent

5) By subtraction AX+X (100 visual percent) = 100 wt. percent

6) Solving for X by division $X = \frac{\text{100 wt. percent}}{\text{A+100 visual percent}}$

Table 13

Clay Minerals in Part of the Hughes Creek Shale

Bedding Number	Most Abundant	2nd Most Abundant	3rd Most Abundant
W-9	Illite	Chlorite	
W-8	Illite	Chlorite	
L-10	Illite	Vermiculite	
L-8	Illite	Vermiculite	
BR-4b	Illite	Vermiculite	
BR-3-2	Illite	Vermiculite	
BR-3-1	Illite	Vermiculite	
DC-7d	Illite	Chlorite	Illite-Vermiculite Random Interlayer
DC-7b	Illite	Chlorite	
DC-6	Illite	Chlorite	Illite-Vermiculite Random Interlayer
P-7b	Illite	Chlorite	
P-6	Illite	Chlorite	Illite-Vermiculite Random Interlayer
P-5b	Illite	Chlorite	Illite-Vermiculite Random Interlayer

INTEGRATION OF BIOTIC AND PETROLOGIC DATA

Vertical Integration

At each locality a series of events took place which are recorded in the rock but diagensis and post-diagenetic effects may obscure and change part of the rock record. Theoretically a clearer picture may be obtained by analyzing as many parameters as possible. Figures 12-16 integrate data obtained from petrologic and biotic analysis and the dendrograms indicate similarities of biotic assemblages on bedding surfaces. General trends noted are 1) assemblages within the lower part of the mudstone are more alike (i. e. Dice correlation coefficient was higher than are assemblages in the upper part, 2) diversity increases from the bottom to a peak usually in the lower part of the middle mudstone then declines, 3) grain size in the lower bed increases upward at most localities, and 4) weight percent of insoluble residues increases toward the center of the mudstone then decreases. Complete trends of these variables in this interval will be more meaningful when data from the carbonate units (Schmidt, in preparation) are available.

Data from the argillaceous micritic limestone (upper bed) will probably be more like limestone bedding surfaces above and below it than like the mudstone (lower bed). Where more than one surface was mapped in this upper bed, the Dice correlation coefficient indicates these upper bed surfaces are more similar to each other than to bedding surfaces in the mudstone (figs. 13 & 16).

Dendrograms illustrate two general relationships between bedding surface fossil assemblages in the mudstone (lower bed) and argillaceous micritic limestone (upper bed) 1) assemblages in the upper part of the lower bed are most similar to those of the upper bed (fig. 13, 14, 15, and 16) and 2) all mudstone assemblages are more similar to each other than to those of the upper bed (fig. 12). I believe the former is more realistic because fossil

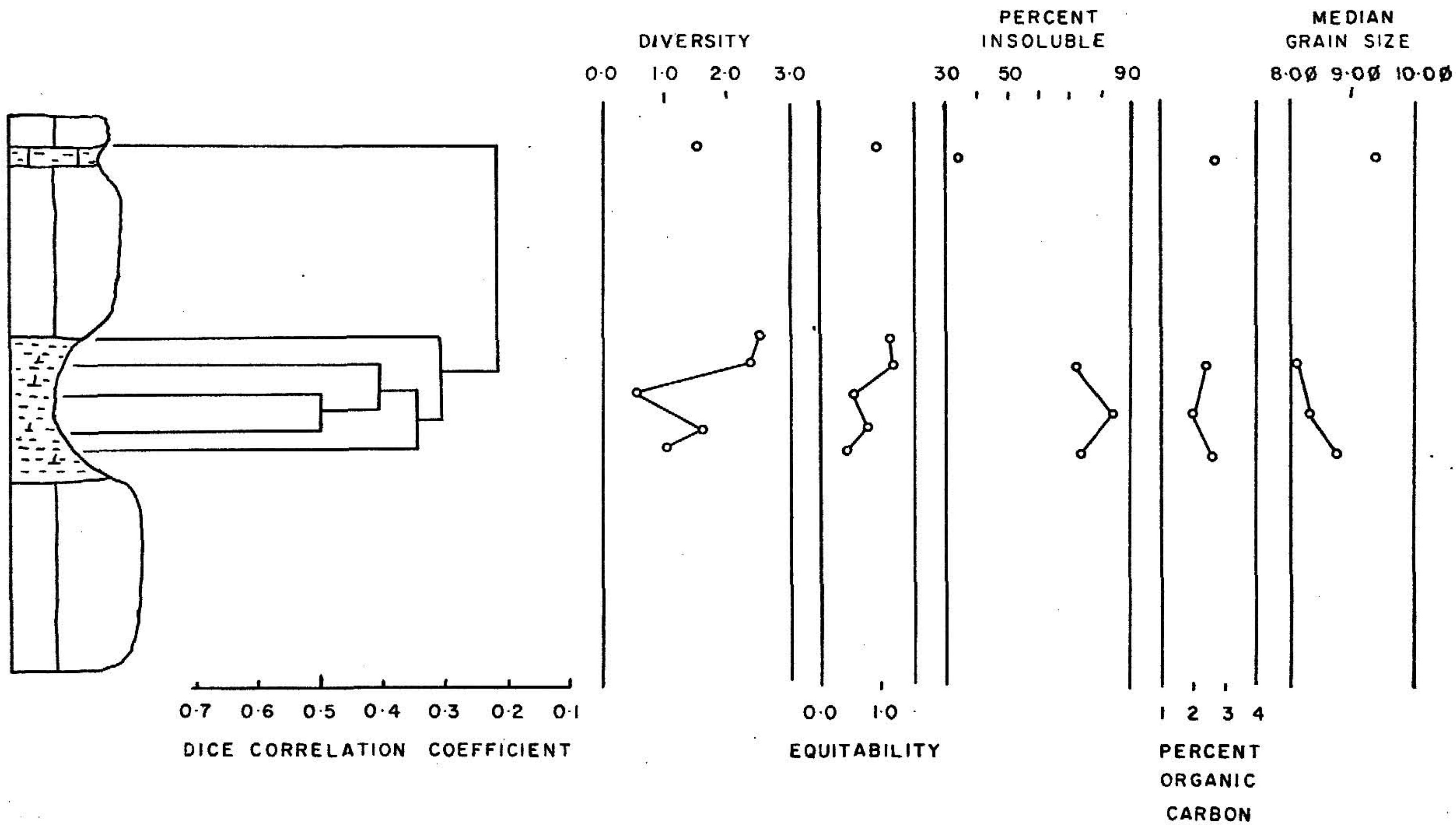


Figure 12. Integration of Data from Locality W of Part of the Hughes Creek Shale.

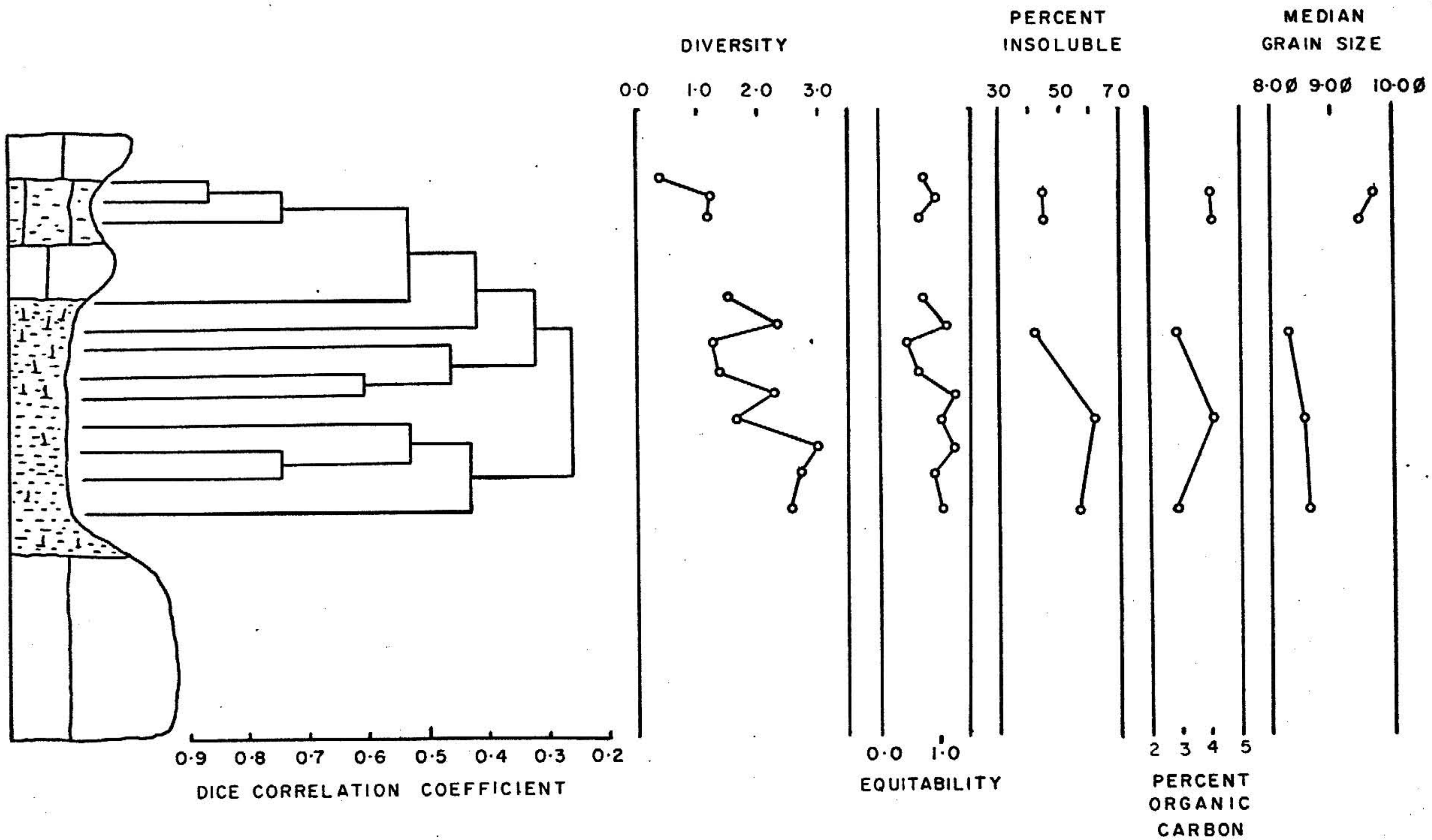


Figure 13. Integration of Data from Locality L of Part of the Hughes Creek Shale.

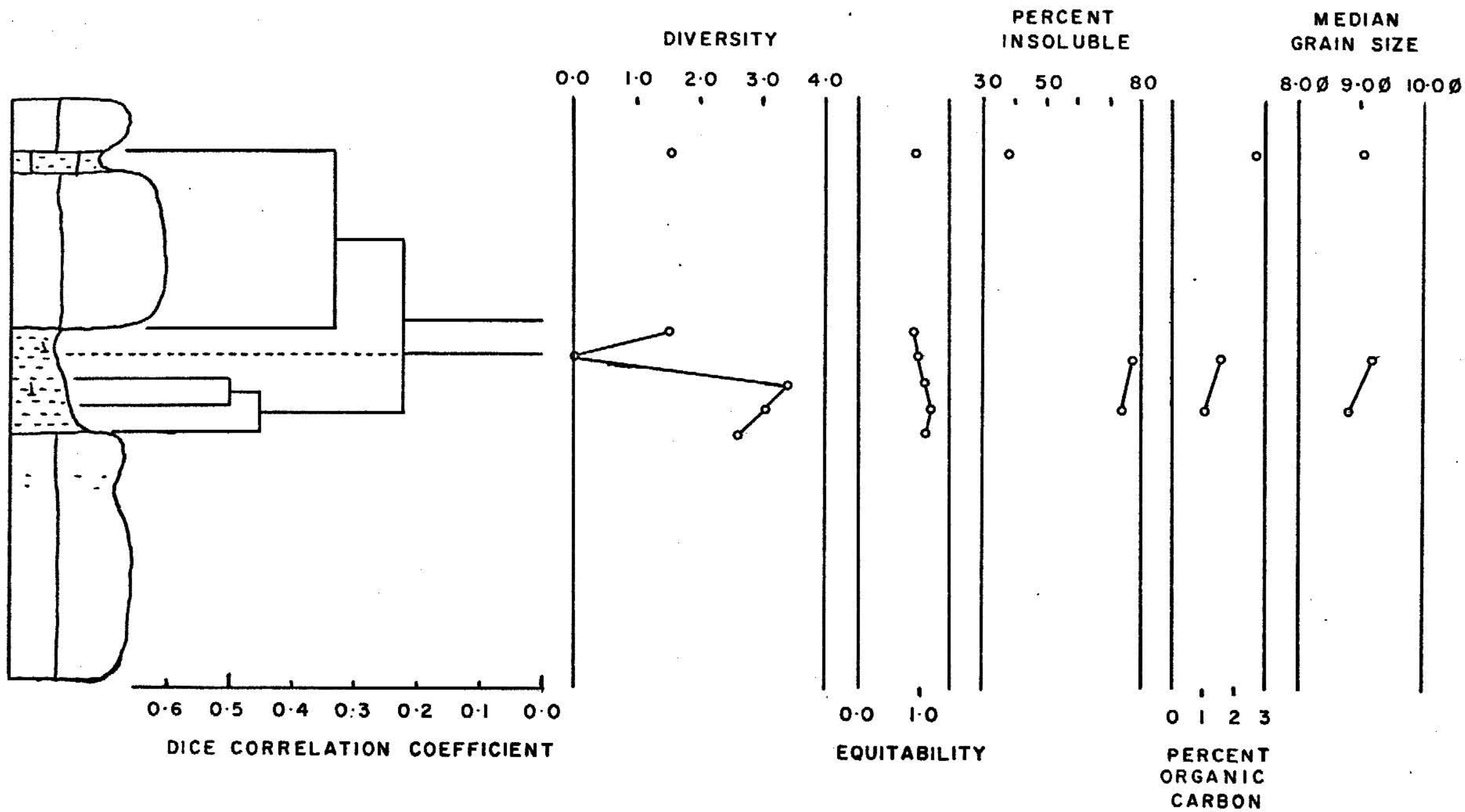


Figure 14. Integration of Data from Locality BR of Part of the Hughes Creek Shale.

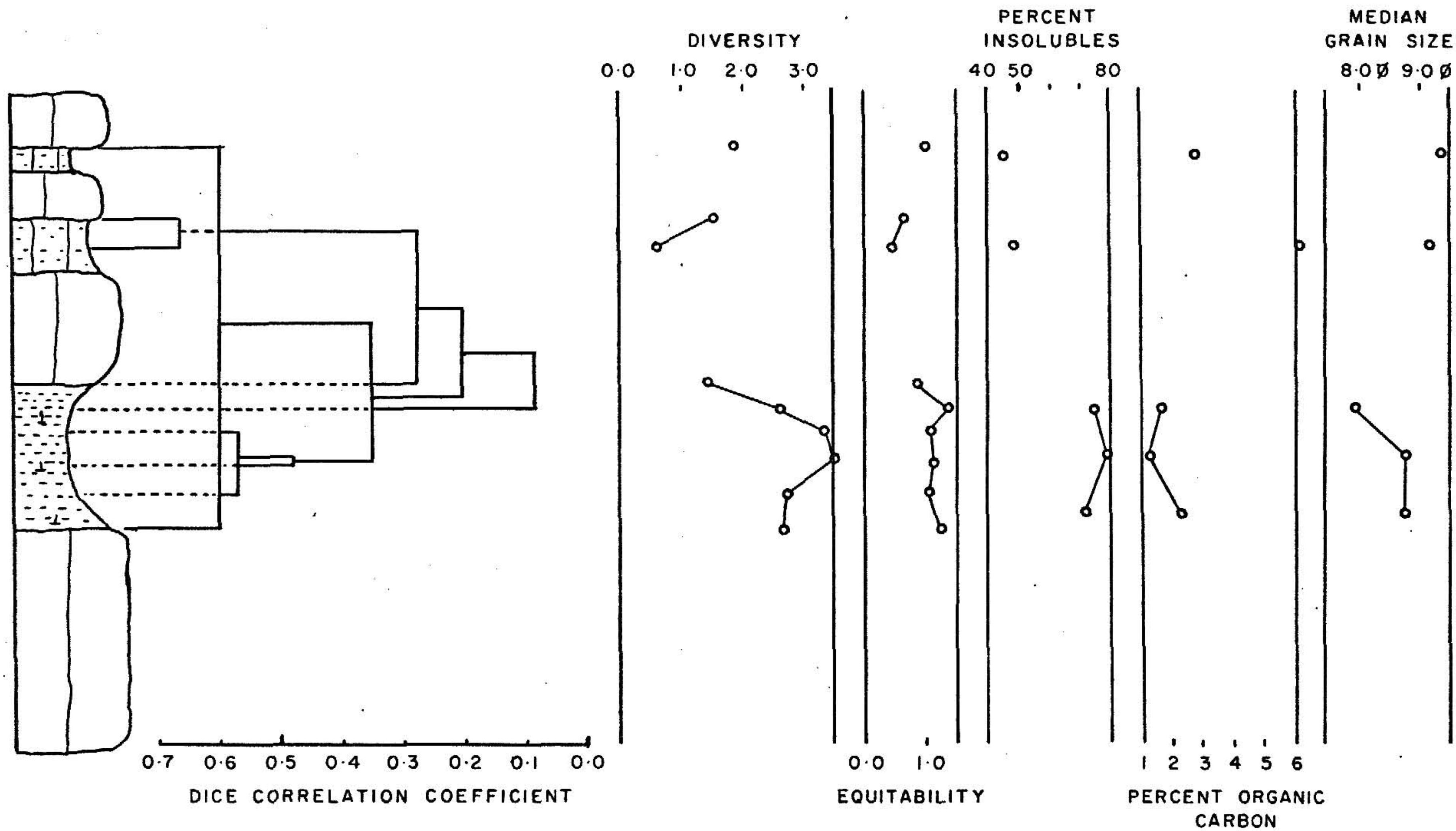


Figure 15. Integration of Data from Locailty DC of Part of the Hughes Creek Shale.

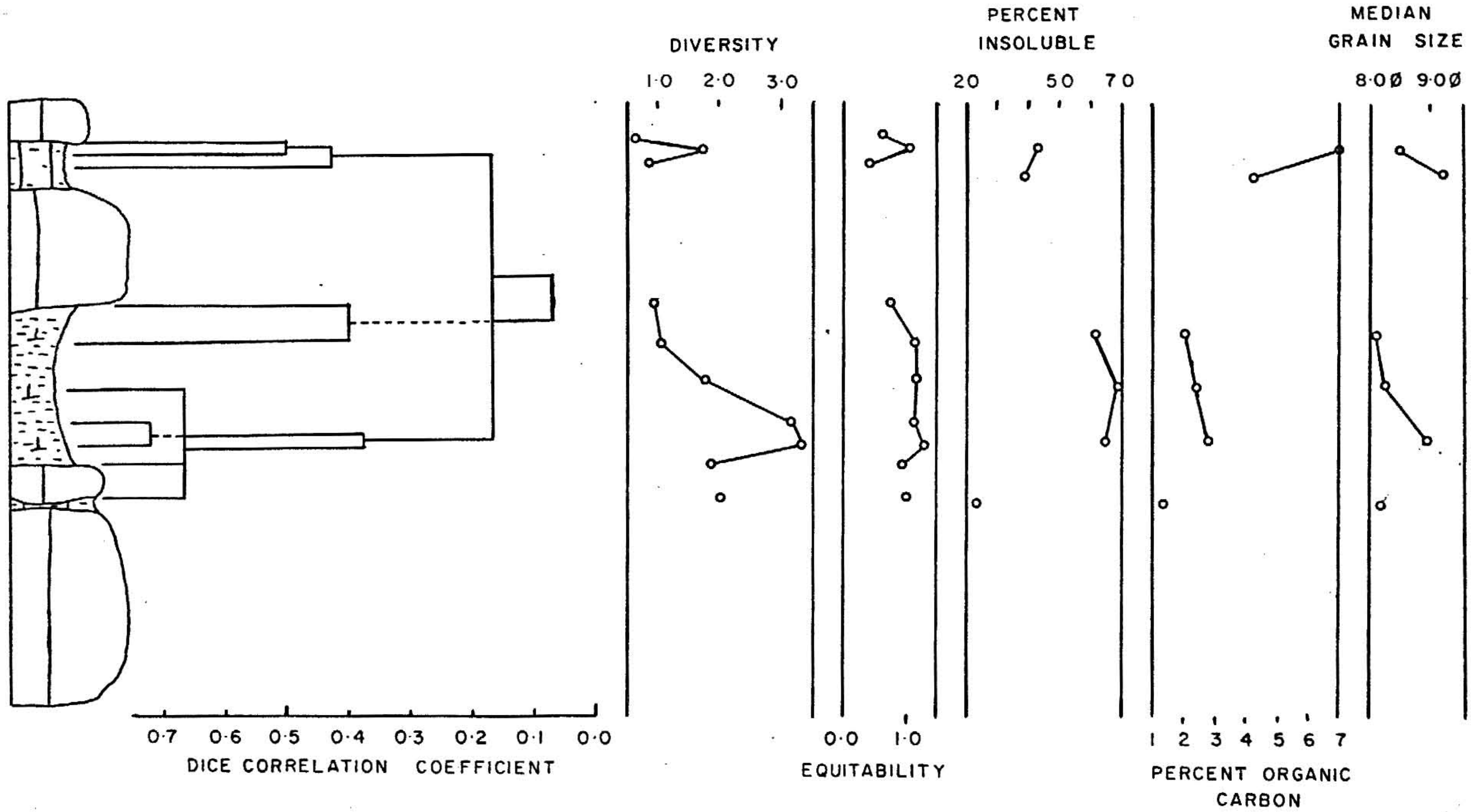


Figure 16. Integration of Data from Locailty P of Part of the Hughes Creek Shale.

assemblages of the upper part of the mudstone are vastly different from those at the base. The latter relationship is probably the result of sample bias (see Table 2).

This pattern suggests cyclicity and Mudge and Yochelson (1962) implied that this stratigraphic interval (their unit 2) belonged to an incomplete cyclothem with the upper and lower beds of limestone representing phase 7 and the mudstone phases 6 and 3 (fig. 16). These are phases defined by Elias (1937) and my use of them is not meant to imply water depth but rather to indicate general biotic changes and relative position with respect to strand line. I would place the mudstone in phases 5 to 7 because the lower part of the mudstone contains brachiopods and bivalves and the upper part contains fusulinids at locations L, DC, and P indicating at least part of phase 7. Occurrence of lingulids in the argillaceous micritic limestone (my upper bed) indicates phase 3. If the limestone between my two units (part of Schmidt's investigation) belongs to phases 4 through 6, a nearly complete cyclothem would be present. My interpretation is supported by the relative low degree of similarity between the upper and lower part of the mudstone (see figs. 12-15). The fossil assemblage from bed DC-7d correlates at the 0.6 level with the lowermost fossil assemblage from DC-6 indicating the approximate middle (phase 5) of another cycle (fig. 14) for this bed (DC-7d).

Median grain size gradually increases upward in the mudstone and is significantly smaller in the argillaceous micritic limestone (Table 9). This does not seem reasonable because grain size usually decreases away from the source and if the upper bed was deposited nearer shore (phase 3) it is reasonable to assume that it was closer to the source area. It is important to remember that grain size is a function of both source area and energy

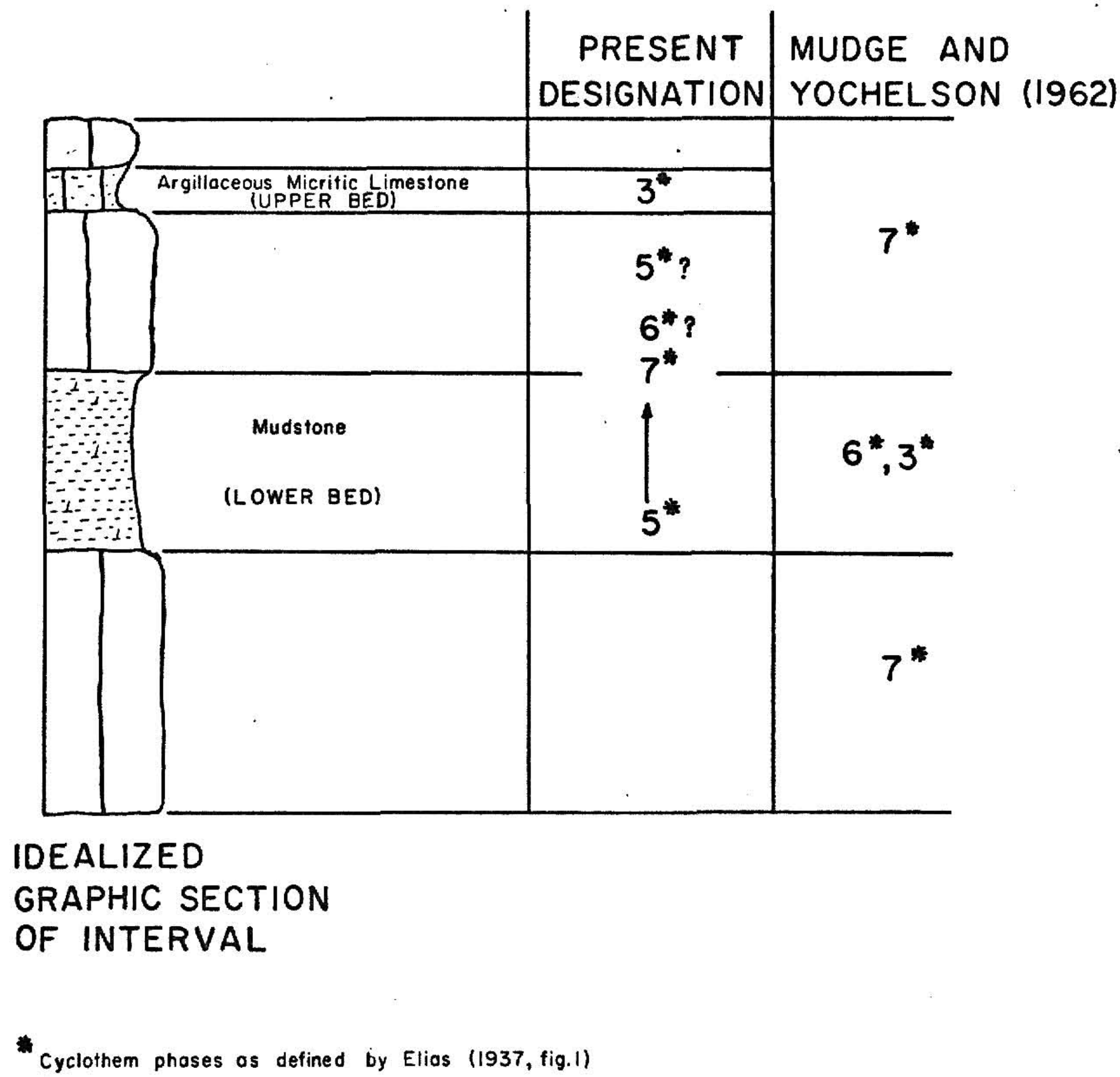


Figure 17. Idealized Graphic Section Showing Possible Cyclothem Phases.

available for transportation. As water depth decreases, areas where silts and clays had recently been deposited could be exposed and served as source areas for the upper parts of the interval. As water depth increases distance to the source area would also increase with a possible increase in the availability of more large grains. Passega (1957) suggested that the coarsest one percentile is an indicator of available energy and figure 11 shows that the coarsest one percentile of the upper bed is larger at most localities. This would indicate that more energy was available for sediment transport during deposition of the argillaceous micritic limestone.

Ecological parameters of fossil assemblages at each locality were computed by calculating the percentage of individuals in each mode of life and feeding behavior for each bed (Table 14). Statistical X^2 tests were calculated to test whether any significant difference existed between upper and lower beds in terms of infaunal and epifaunal forms and high level and low level suspension feeders (Table 14). No significant change in feeding behavior and mode of life would indicate that species in the assemblages, not ecological strategies, were changing. If biovolume were used as suggested by Walker (1972) instead of numbers of individuals more meaningful results might be possible.

Lateral Integration

The fossil assemblages appeared nearly the same at all localities but to test the degree of similarity a Q mode cluster analysis was performed using the Dice correlation coefficient. If the Nemaha Anticline did not affect the biotic assemblages, I would expect, in general, greatest similarity between adjacent geographic localities. To test this idea the second bedding surface above the base of the mudstone was chosen to allow some stabilization of the environment following carbonate deposition of the lower limestone bed. Figure

Table 14

Ecological Parameters and Statistical Comparisons between Beds of Part of the Hughes Creek Shale

Bed Number	Mode of Life						Feeding Behavior							
	Infaunal		Epifaunal		Nectonic		High Level Suspension		Low Level Suspension		Collecters		Carnivores	
	#	%	#	%	#	%	#	%	#	%	#	%	#	%
W-9b ##	6	26	17	74			14	61	9	39				
W-8#	38	45	46	55			46	46	38	45				
L-10##	3	9	32	91			27	77	8	23				
L-8#	14	11	110	88	1	1	72	58	17	14	35	28	1	1
BR-4b##	2	14	12	86			9	64	5	36				
BR-3#	16	23	52	77			53	76	16	23			1	1
DC-7d	6	46	6	46	1	8	6	46	6	46			1	8
DC-7b##	20	23	67	77			51	59	36	41				
DC-6##	21	22	74	78			66	69	24	25	5	5		
P-7b##	19	24	58	74	1	1	61	78	15	19	1	1	1	1
P-6#	8	12	61	88			44	64	16	23	9	13		
P-5b	2	25	6	75			6	75	2	25				

	# Individuals High Level Suspension Feeders	# Individuals Low Level Suspension Feeders	Total	#Individuals Epifaunal	#Individuals Infaunal	Total
Upper ## Bed	162	67	229	186	50	236
Lower # Bed	281	118	339	345	97	442
Total	443	185	628	531	147	678
	$X^2 = 0.00$				$X^2 = 0.02$	

X^2 values must be greater than 3.84 for a significant difference to exist at the 0.05 level

18 is a dendrogram based on assemblages from an equivalent bedding surface (second above the limestone) at all 5 localities. The highest Dice correlation coefficient value (0.71) between adjacent localities indicates that the Nemaha Anticline had little effect on assemblages during this phase of deposition. Total assemblages at each locality were clustered with the resulting dendrogram (fig. 19) showing a different relationship. Localities BR and P, which are on opposite sides of the Nemaha Anticline, are most alike while locality W (a northern exposure) is more like the combination of localities BR and P (southern exposure) than any other localities. Localities L and DC have similar values (0.62 and 0.61 respectively), but DC is geographically between P and BR. This indicates that the Nemaha Anticline must have had some effect on the total fossil assemblage in this interval.

A one way analysis of variance of number of infaunal and epifaunal individuals and high level and low level suspension feeders within the total stratigraphic interval indicates that no significant difference between localities exists at the 0.05 level (Table 15). Assuming no sample bias this indicates that although the species present were influenced by the Nemaha Anticline, ecological strategies (mode of life and feeding behavior) were not. A possible cause for nonsignificance of this test could be that variance within each locality was high compared to variance between localities (see Table 15).

One way analysis of median grain size (Table 16) indicates that this parameter was significantly different between localities. Localities that appear to have anomalous values (L and BR) also contain clay minerals that indicate weathering which could decrease grain size.

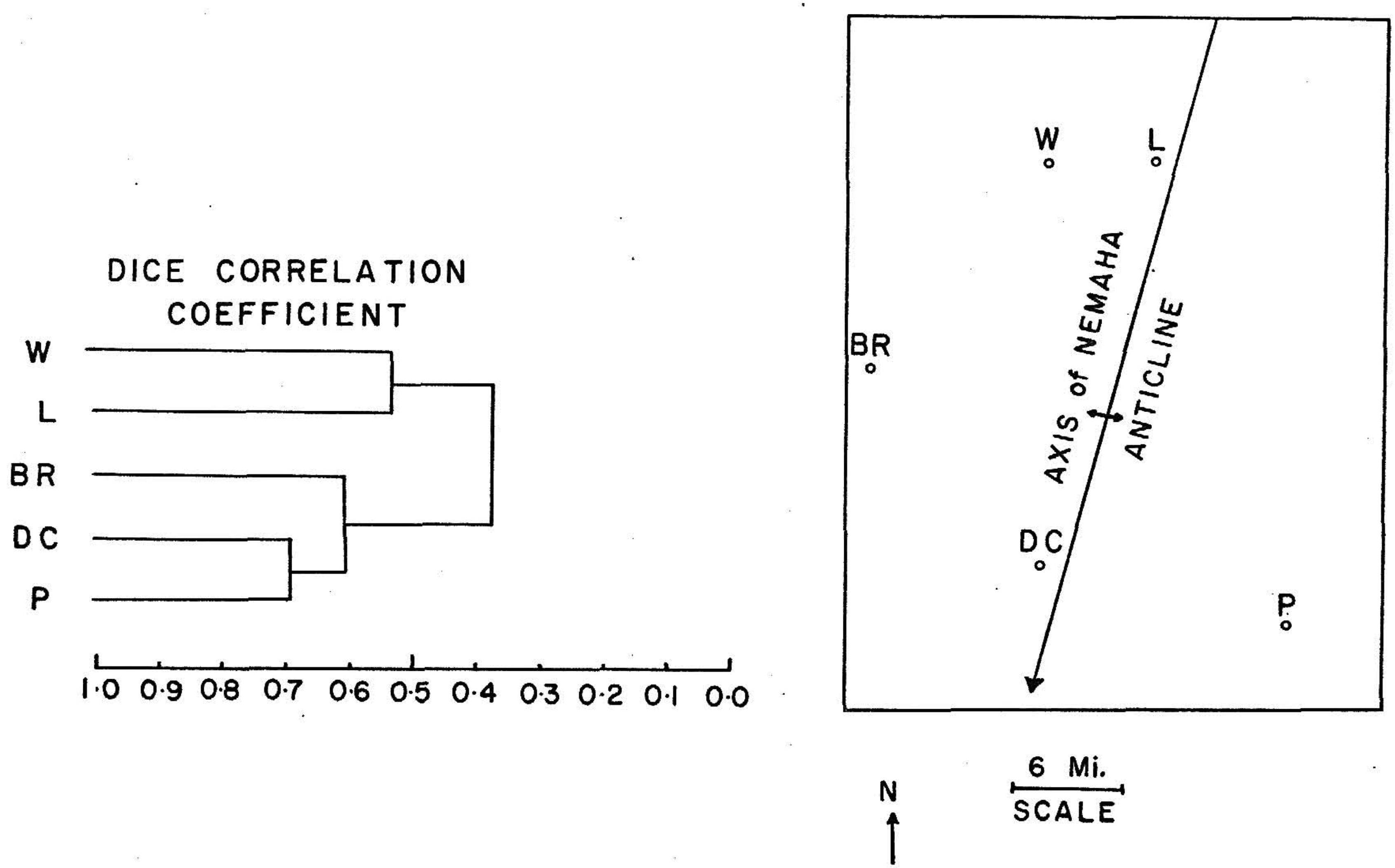


Figure 18. Dendrogram Indicating Similarity Between One Bedding Surface at All Localities of Part of the Hughes Creek Shale.

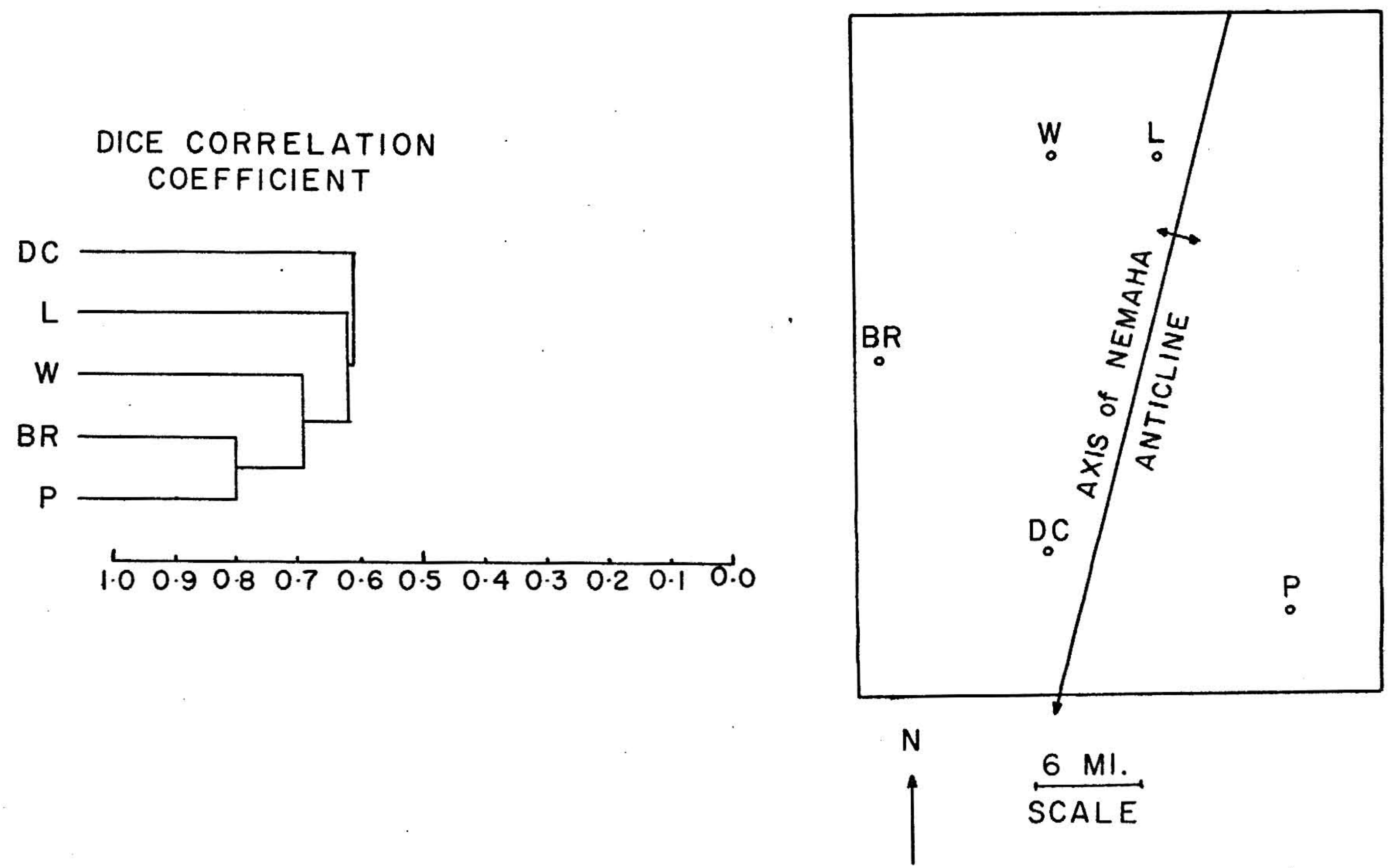


Figure 19. Dendrogram Indicating Similarity Between All Bedding Surfaces at All Localities of Part of the Hughes Creek Shale.

Table 15

One Way Analysis of Variance of Ecological Strategies between Localities in Part of the Hughes Creek Shale

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	F
# of Infaunal Individuals				
Between Localities	4	318.6	79.6	
Within Localities	5	731.5	146.3	0.544
Total	9	1050.1		
# of Epifaunal Individuals				
Between Localities	4	3069.4	767.4	
Within Localities	5	4373.5	874.7	0.877
Total	9	7442.9		
# of High Level Suspension Feeders				
Between Localities	4	1354.6	338.6	
Within Localities	5	2749.5	549.9	0.616
Total	9	4104.1		
# of Low Level Suspension Feeders				
Between Localities	4	532.4	133.1	
Within Localities	5	694.0	138.8	0.959
Total	9	1226.4		

If $F < 6.26$ no significant differance at 0.01 level

Table 16

One Way Analysis of Variance of Grain Size between Locations in Part of the Hughes Creek Shale (Beds DC-7d and P-5b Omitted)

Source of Variance	Degrees of Freedom	Sum of Squares	Mean Square	F
Between	4	1324.9	331.2	
Within	16	4.2	.26	1273.8*
Total	20	1329.1		

* indicates that a significant difference exists at the 0.05 level

Summary

Biotic and petrologic data indicate a change between two beds in this stratigraphic interval. A possible explanation for this difference is that the two beds represent two different phases of a cyclothem, however, no significant difference in ecologic aspects of the fossil assemblage within the interval is noted. Grain size increases upward within the lower bed but decreases in the upper bed and is thought to be a function of proximity of source area. The coarsest one percentile indicates that more energy was present in the upper bed although median grain size is smaller.

Lateral changes within this interval are not apparent in the lithology. Q mode analysis of fossils on one surface in the mudstone at all five localities indicates that geographically adjacent localities have similar fossil assemblages. When total assemblages within the interval are clustered using this method differences are noted that are attributed to the Nemaha Anticline. One way analysis of variance indicates that grain size is significantly different at the two most severly weathered localities but that the Nemaha Anticline produced no difference in ecological strategies.

ACKNOWLEDGMENTS

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Last, and most important, I wish to express my gratitude to my wife, Linda, for aid and encouragement throughout this study and especially for typing and editing the manuscript.

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APPENDIX I

This appendix contains field descriptions of the interval studied. Color designations are in terms of Goddard, et al., 1963. Recorded hardness is a relative value using the following scale: the upper bed of the Americus Limestone was defined as very hard and the softest mudstone encountered was defined as soft. Mud percentages were estimated in the field using a 10X hand lens and the visual percentage charts of Terry and Chilingar (1955). Fossils are listed in order of abundance based on field observations. Strike and dip of joints are recorded to the nearest degree and when more than one attitude was observed the values are separated by a semicolon (strike and dip are separated by a comma). Two numbers are used for bed designation, the first one is the field number and the second, in parentheses, is the laboratory number and the one used in this report.

WESTMORELAND (W) SECTION

Date measured: 16 July, 1974 Measured by: G. R. Yarrow

Locality: NE¼, NE¼, SW¼, Sec. 3, R9E, T8S, Pottawatomie County, Kansas; a "fresh" stream bank cut (nearly vertical) with Rock Creek flowing on the upper bed of the Americus Limestone and the top of the bank is in the Eskridge Shale. Total thickness of the Hughes Creek Shale is 10.32 meters.

Bed No.	Description	Thickness
W-B7 (W-7)	Micritic limestone, gradational contacts above and persistent throughout outcrop.	27 cm.

Color: Weathers grayish orange pink (5YR7/2), unweathered grayish orange pink (5YR7/2).

Bedding: Distinguished from beds above and below by being more resistant to weathering, top 7 cm. separated from lower massive 20 cm. by a parting plane, bedding surfaces nearly flat.

Composition: Micritic calcite cement, less than 10% mud, smells of sulfur when struck with rock hammer (pyrite?).

Fossils: Crinoid debris, echinoid spines, unidentifiable brachiopods, Hustedia (non-life position i.e. pedicle valve down) and fish debris.

Joints: None observed.

Bed No.	Description	Thickness
W-B8 (W-8)	Calcareous mudstone, gradational contact above and below, persistent throughout outcrop.	20 cm.

Color: Weathers medium light gray (N6), unweathered dark gray (N3).

Bedding: Distinguished from units above and below by being less resistant to weathering, blocky fracture, parting of mudstone at 0.5 cm. intervals.

Composition: Calcareous clay and silt size grains, pyrite infillings of burrows, lower 3-5 cm. iron oxide stained.

Fossils: Neochonetes (articulated, cast of fenestrate Ectroproct, Crurithyris, Neospirifer, Derbyia, Linoproductus (generally in hydrodynamically stable position), ramose ectroprocts, crinoid debris.

Joints: None observed.

W-B9a (W-9a) Soft argillaceous micritic limestone, gradational contacts above and below, persistent throughout outcrop. 23 cm.

Color: Weathers pale yellowish brown (10YR6/2), unweathered medium gray (N5).

Bedding: One massive bed, distinguished from beds above and below by being more resistant to weather and color change, upper contact very gradational, surface rough with few fossils weathering in relief throughout the unit.

Composition: Micritic calcite cement, 20-30% mud.

Fossils: Criniod debris, fusulinids (randomly oriented), fish debris, fenestrate and ramose Ectroprocts, Wilkingia (life position i.e. inclined to bedding) 3.5 cm. long, fusulinids and crinoid debris in lower part, overlain by middle part containing fish debris and upper part containing few fossils.

Joints: N19°E, 89°E.

W-B9b (W-9b) Argillaceous micritic limestone, gradational contact above and below, appears thicker where more weathered. 3 cm.

Color: Weathers medium dark gray (N4), unweathered medium dark gray (N4).

Bedding: Distinguished from beds above and below by being less resistant to weathering, fissle.

Composition: Micritic calcite cement with nearly 50% mud.

Fossils: Large numbers of Crurithyris (Pedicle up and/or down, majority oriented with pedicle valve down).

Joints: Oriented as in bed W-B9a.

W-B9c (W-9c) Argillaceous micritic limestone, gradational contact above and below, appears persistent throughout outcrop. 5 cm.

Color: Weathers medium dark gray (N4), unweathered grayish black (N2).

Bedding: Distinguished from units above and below by being more resistant to weathering.

Composition: Micritic calcite cement, estimate 10-20% mud, carbonaceous.

Fossils: Lower part dominated by Crurithyris (pedical valve down) and Lingula (parallel to bedding), upper part horizontally burrowed with star shaped burrows, a few crinoid columnals and Hystriculina.

Joints: Oriented as in bed W-9a.

LOUISVILLE (L) SECTION

Date Measured: 9 Aug., 1974 Measured by G. R. Yarrow

Locality: NW¼, NW¼, NW¼, Sec. 9, R10E, T8S, Pottawatomie County Kansas; Starts in a road ditch 40 meters east of intersection with a north-south county road and ends near the top of a hill east of intersection. This section appears more weathered than the other four sections. Total thickness of Hughes Creek Shale is 10.69 meters.

Bed No.	Description	Thickness
L-B7 (L-7)	Medium hard micritic limestone, sharp contact above and below, persistent throughout outcrop.	27 cm.

Color: Weathers grayish orange (10YR7/4), unweathered medium gray (N5) mottled moderate yellow orange (10YR6/4).

Bedding: Wavy bedded, splits into beds 6-9 cm. thick, distinguished from units above and below by being more resistant to weathering (ledge former), bedding surfaces are uneven but rounded, upper 8-10 cm. is more argillaceous than lowerpart and weathers in less relief, fossils weather in slight relief, mottled and appears burrowed.

Composition: Micritic calcite cement, 10-20% mud with some iron oxide fracture filling, dendrites on bedding surfaces.

Fossils: Fragmented fossil debris (30-40% brachiopods) crinoid debris, Pteronites (parallel to bedding), *Neospirifer* (hydrodynamically stable, both disarticulated and articulated), in upper 5 cm. *Punctospirifer*, branching vertical and/or horizontal burrows 0.2 - 0.3 cm. in diameter and in the upper part of the bed carbonized plant fragments.

Joints: S25°E, 88°W; N28°E, 75°N.

L-B8 (L-8) Soft calcareous mudstone, sharp contact below, gradational above, persistent throughout outcrop. 33 cm.

Color: Covered by slump, unweathered light brown (5YR5/4) mottled dark gray (N3).

Bedding: Blocky to flaky, weathers crumbly, distinguished from unit above by being less resistant to weathering. Lower and upper portion (5-10 cm.) more calcareous than middle.

Composition: Silt and clay grains with silt being most abundant, calcareous, iron oxide stains between bedding surfaces and throughout lower 5 cm.

Fossils: *Crurithyris* (pedicle valve up and/or down) most abundant fossil in lower part decreasing upward, absent in middle and upper part, *Hystriculina* associated with *Crurithyris* in lower part, crinoid columnals are associated with *Crurithyris* and increase upwards, *Neochonetes*, *Neospirifer* (disarticulated and articulated), and *Aviculopecten* molds occur in the middle and upper part. Other fossils on the weathered outcrop are corals *Reticulatia*, *Composita* and *Hustedia*.

Joints: None observed.

L-B9 (L-9) Medium to medium hard argillaceous micritic limestone, gradational contact below and above, persistent throughout outcrop but variable in thickness. 8-10 cm.

Color: Weathers moderate orange (5YR8/4), unweathered dark gray (N3) mottled grayish orange pink (5YR7/2).

Bedding: One bed, distinguished from units above and below by being more resistant to weathering, surface is uneven because of weathering along joints, uneven fracture, appears burrowed (mottled).

Composition: 30-40% mud, micritic calcite cement, iron oxide stains of burrow fillings.

Fossils: 10% of rock, Orbiculoidea fragments most abundant in lower half of bed, Hystriculina (non-life i.e. pedicle valve up), Rhipidomella (non-life i.e. pedicle valve down) and burrows.

Joints: 8-12 cm. apart, S 69°E, 77°E; N 56°E, 80°N.

L-B10 (L-10) Soft argillaceous micritic limestone, gradational contact below and above, persistent throughout outcrop. 10 cm.

Color: Covered by slump, unweathered moderate yellowish brown (10YR5/2).

Bedding: Blocky to flaky weathers crumbly, distinguished from unit above and below by being less resistant to weathering (slope former), upper and lower part more calcareous than middle.

Composition: Silt and clay with dominance of clay, micritic calcite cement, iron oxide staining between parting planes.

Fossils: Crurithyris (pedicle valve up and/or down) consisted of 80-90% of fossils, other fossils were Orbiculoidea, crinoid debris and unidentifiable fragments.

Joints: None observed.

L-B11 (L-11) Medium hard argillaceous micritic limestone, gradational contacts below and above, persistent throughout outcrop. 6 cm.

Color: Covered by slump, unweathered grayish black (N2) mottled moderate brown (5YR4/4).

Bedding: One bed, distinguished from units below and above by being more resistant to weathering, parting planes 1-2 cm. apart, fractures around fossils parallel to bedding, uneven fracture across bedding, forms part of covered slope.

Composition: 30-40% mud, micritic calcite cement, iron oxide staining along joints; iron oxide staining of burrows.

Fossils: Crurithyris (pedicle valve up and/or down) 70-80% of fossils, other fossils are Orbiculoidea, Wellerella (disarticulated), Acanthopecten, and burrows.

Joints: S 29°E, 82°W; N 64°E, 74°N.

BLUE RIVER (BR) SECTION

Date measured: 22 Jan., 1972

Measured by: G. R. Yarrow
J. V. Miesse
K. A. Shewell
D. L. Pearson

Locality: NE¼, SW¼, SE¼, NE¼, Sec. 30, T9S, R8E, Pottawatomie County, Kansas road cut on north side of road. The lower part of this unit appears to be weathered at the outcrop. Total thickness of Hughes Creek Shale was obtained by measuring the lower part at a nearby locality and is 7.25+ meters.

Bed No.	Description	Thickness
BR-B2a (BR-2a)	Argillaceous micritic limestone, gradational contact below and above.	20 cm.
	Color: Unweathered, light gray (N7) to light olive gray (5YR5/6) stained grayish orange (10YR7/4) to light brown (5YR5/6).	
	Bedding: One bed. Distinguished from beds above and below by being more resistant to weathering.	
	Composition: Micritic calcite cement, argillaceous.	
	Fossils: Small fossil fragments with some algal coated grains.	
	Joints: No information taken.	
BR-B2b (BR-2b)	Argillaceous micritic limestone, gradational contact above and below.	6 cm.
	Color: Unweathered, light gray (N7) mottled grayish orange (10YR7/4).	
	Bedding: Distinguished from beds above and below by being slightly less resistant to weathering.	

Composition: Micritic calcite cement, more argillaceous than beds above and below. Iron oxide staining.

Fossils: Composita, Hustedia, Derbyia (fragments), productids (non-life position i.e. pedical valve up), fossils more broken than in unit above.

BR-B2c (BR-2c) Micritic limestone, gradational contact above and below. 5 cm.

Color: Unweathered, medium dark gray (N4) to light olive gray (5YR6/1) mottled areas grayish orange (10YR7/4) to dark yellowish orange (10YR6/6).

Bedding: Distinguished from beds below and above by being more resistant to weathering.

Composition: Micritic calcite cement.

Fossils: More than units below and above, most are complete specimens, Derbyia, Neochonetes, few Crurithyris, chitnophosphatic fragments, and echinoid spines.

Joints: No information taken.

BR-B3 (BR-3) Calcareous mudstone, gradational contact above and below. 15 cm.

Color: Unweathered olive gray (5Y4/1) to dark greenish gray (5GY4/1) mottled gray orange (10YR7/4) to light brown (5YR5/6).

Bedding: Distinguished from beds below and above by being less resistant to weathering, blocky.

Composition: Silt and clay grains, calcareous, iron stained zone in middle.

Fossils: 4 cm. from top is a zone of Neochonetes 2 to 3 valves thick, 9 cm. from top is a zone of productids, Reticulatia, Myalinid clams, Neospirifer, unbroken fenestrate Ectoprocts, Crurithyris, Linoproductus, and Derbyia, thin zone is iron stained; other fossils in the unit are Hustedia, Hystriculina, Rhipidomella, crinoid debris, echinoid spines, and ramose Ectoprocts.

Joints: No information taken.

BR-B4a (BR-4a) Micritic limestone, gradational contacts below and above. 20 cm.

Color: Unweathered, medium gray (N5) to light olive gray (5Y6/1) stained dark yellow orange (10YR6/6).

Bedding: Distinguished from bed above and below by being more resistant to weathering.

Composition: Micritic calcite cement.

Fossils: Fusulinids abundant in lower 6 cm., other fossils observed are: Hustedia, Composita, Neospirifer, Hystriculina, Reticulia (inferred life position i.e. pedicle valve down), Rhipidomella, Derbyia, and Orbiculoidea fragments.

BR-B4b (BR-4b) Calcareous carbonaceous shale, gradational contact below and above. 3 cm.

Color: Unweathered medium gray (N5) to dark gray (N3) mottled light olive gray (5Y6/1), some iron stains dark yellow orange (10YR6/6).

Bedding: Distinguished from unit above and below by being less resistant to weathering, fissle.

Composition: Carbonaceous, calcareous, with some iron stains.

Fossils: Crurithyris (pedicle valve down and/or up), Hystriculina, and Rhipidomella.

BR-B4c (BR-4c) Micritic limestone, gradational contact below and above. 6 cm.

Color: Weathered, grayish orange (10YR5/4) to moderate yellowish brown (10YR5/4), unweathered, mottled pale yellow brown (10YR6/2) to medium gray (N5) to grayish black (N2).

Bedding: Distinguished from unit above and below by being more resistant to weathering.

Composition: Micritic calcite cement.

Fossils: Fish bone fragment, Lingula, Myalinid clams, Hustedia, and evidence of burrowing and reworking.

DEEP CREEK (DC) SECTION

Date measured: 28-30 July, 1974 Measured by: G. R. Yarrow

Locality: NE¼, SE¼, NW¼, Sec. 14, R8E, T11S, Riley County, Kansas; stream cut where Deep Creek changes direction from east to north eroding the bank into the lowermost mudstone of the Hughes Creek Shale. This outcrop shows slight weathering characteristics (i.e. some roots in the mudstone) but contains no vegetation cover. Total Hughes Creek Shale thickness was obtained by measuring the non-exposed interval down stream (about 150 M.) where Deep Creek cuts through the Americus Limestone. Total thickness of the Hughes Creek Shale is 9.87+ meters.

Bed No.	Description	Thickness
DC-B5 (DC-5)	Medium hard micritic limestone, sharp contact below, gradational above, persistant throughout outcrop.	29 cm.
	Color: Weathers grayish orange (5YR7/12), stained dark yellowish orange (10YR6/6), unweathered medium dark gray (N4).	/
	Bedding: Massive, uneven fracture, distinguished from units above and below by being more resistant to weathering.	
	Composition: Micritic calcite cement with 10-20% mud, iron oxide filled vugs and cracks, and sparry calcite filled fossils.	
	Fossils: Crinoid debris, bivalve fragments, <u>Meekella</u> (non-life position i.e. pedicle valve	

up, disarticulated), Pteronities (25 cm. long parallel to bedding, algae?.

Joints: N 46°E, 81°W; S 41°E, 80°W.

DC-B6 (DC-6) Soft calcareous mudstone, gradational contacts below and above, persistent throughout outcrop. 19 cm.

Color: Weathers pale brown (5YR5/2), unweathered dark gray (N3).

Bedding: Crumbly to blocky with numerous fossils weathered in relief, upper part more yellowish than lower part, distinguished from beds above and below by being less resistant to weathering.

Composition: Silt and clay grains, silt dominant, calcareous, some iron oxide staining on bedding surfaces.

Fossils: Reticulatia (brachial valve in hydrodynamically stable position, 5 cm. across), Neochonetes (disarticulated and articulated), Derbyia (disarticulated in hydrodynamically stable position), Hustedia (life position i.e. pedicle valve up), Crurithyris (pedicle valve up and/or down, articulated and disarticulated), Linoproductus (hydrodynamically stable position), ramose Ectoprocts, crinoid debris, and fusulinids.

Joints: None observed.

DC-B7a (DC-7a) Medium hard micritic argillaceous limestone, gradational contact above and below, persistent throughout outcrop. 14 cm.

Color: Weathers light brown (5YR6/6), unweathered medium dark gray (N4).

Bedding: One bed, distinguished from units above and below by change in color and resistance to weathering, uneven fracture, fossil fragments weather in slight relief on vertical face.

Composition: Micritic calcite cement, estimate 30-40% mud, iron oxide stained vugs.

Fossils: Orbiculoidea fragments (most abundant fossil in lower part), Compositia (3 cm. in width), Hystriculina, crinoid debris, fusulinids, Derbyia (disarticulated), and indications of burrowing (mottled texture). Orbiculoidea fragments decrease upwards.

Joints: N 54° E, 82° N; S 24° E, 86° W

DC-B7b (DC-7b) Medium soft argillaceous micritic limestone, gradational contacts above and below, persistent throughout outcrop. 7 cm.

Color: Weathers light gray (N7), unweathered grayish black (N2).

Bedding: Blocky, breaks into pieces 0.3-0.7 cm. thick and 8-14 cm. long, distinguished from beds above and below by being less resistant to weathering.

Composition: Silt and clay grains with an abundance of silt, micritic calcite cement, carbonaceous.

Fossils: 80-90% of fossils are Crurithyris (pedicle valve up and/or down, most articulated, 0.3-1.2 cm. in width), Lingula (maximum length 3.0 cm. oriented parallel to bedding), Edmondia?, crinoid debris and horizontal burrows.

Joints: As in bed DC-B7a.

DC-B7c (DC-7c) Medium hard argillaceous micritic limestone, gradational contact above and below, persistent throughout outcrop. 6 cm.

Color: Weathers grayish orange pink (5YR7/2), unweathered dark gray (N3).

Bedding: One bed, uneven fracture, brachiopod valves observed on weathered surface, distinguished from beds above and below by being more resistant to weathering.

Composition: 30-40% mud, micritic calcite cement, carbonaceous.

Fossils: 95% of fossils are Crurithyris (pedicle valve down, decrease in abundance upward), horizontal and vertical burrows filled with "pellets", unidentifiable nuculid bivalves (some with splayed valves).

Joints: As in bed DC-B7a.

DC-B7d (DC-7d) Soft argillaceous micritic limestone, gradational contact above and below, persistent throughout outcrop. 3 cm.

Color: Weathers pale yellowish brown (10YR6/2), unweathered medium dark gray (N4), mottled light brown (5YR6/4).

Bedding: Flaky partings 0.1-0.3 cm., distinguished from beds above and below by being less resistant to weathering, consists mostly of shells and fragments separated by thin mud layers 0.2-0.3 cm.

Composition: Silt and clay (mostly silt) with micritic calcite cement, some shell fragments iron oxide stained.

Fossils: Crurithyris (most with pedicle valve up), brachiopod fragments, algae?, and appears burrowed (mottled).

Jointing: As in bed DC-B7a.

DC-B7e (DC-7e)	Medium soft argillaceous micritic limestone, gradational contact above and below, persistent throughout outcrop.	7 cm.

Color: Weathers grayish orange pink (5YR7/2), unweathered pale brown (5YR4/2)

Bedding: Wavy, 1-2 cm. thick, distinguished from beds above and below by being slightly more resistant to weathering, uneven fracture and weathers crumbly.

Composition: 40-50% mud, micritic calcite cement, and some iron oxide staining.

Fossils: 60%+ algae coated grains, 10% fusulinids, crinoid debris, brachiopod fragments, Crurithyris (pedicle valve up), and Linoproductus (pedicle valve up).

Joints: As in bed DC-B7a.

PAXICO (P) SECTION

Date measured: 3 Aug., 1974 Measured by: G. R. Yarrow

Locality: SE¼, NE¼, SW¼, Sec. 27, R11E, T11S, Wabaunsee County, Kansas; road cut on northeast side of I-70 near the bridge over Mill Creek. The stratigraphic interval was measured on the road cut 10 meters southeast of the east guard rail end post. Although this outcrop has been exposed several years, little weathering is apparent. Total thickness of the Hughes Creek Shale is 11.37 meters.

Bed No.	Description	Thickness
P-B5a (P-5a)	Hard micritic limestone, sharp contact below, gradational above, persistent throughout outcrop.	22 cm.
	Color: Weathers light gray (N5), unweathered medium gray (N5).	
	Bedding: Massive, weathers nearly smooth, uneven fracture, distinguished from unit above and below by being more resistant to weathering (ledge former), some fossils weather in relief, upper surface slightly undulating, fracture in upper part wavy.	
	Composition: Micritic calcite cement, estimate mud fraction less than 10%, pyrite burrow fillings.	
	Fossils: Bivalve fragments parallel, inclined, and perpendicular to bedding, Neospirifer (disarticulated, concave up), Hystriculina (near top of bed in inferred life position i.e. pedicle valve down), crinoid debris and fusulinids occur throughout the unit with less than	

one specimen per square decimeter of vertical surface, bottom surface appears burrowed.

Joints: Well defined 5-20 cm. apart, N 72°E, 80°E; S 20°E, 88°S.

P-B5b (P-5b) Medium soft calcareous mudstone, variable thickness, gradational contact below and above, persistent throughout outcrop. 1-3 cm.

Color: Weathers medium gray (N5), unweathered medium dark gray (N4).

Bedding: Platy weathers flaky, distinguished from unit above and below by being less resistant to weathering, unweathered very hard to distinguish from units above and below.

Composition: Clay and silt grains with clay dominant, calcareous cement and carbonaceous.

Fossils: Burrows, brachiopod fragments, Crurithyris (patchy distribution), fossil assemblage similar to that of overlying bed (P-B5a).

Joints: Not observed in this unit.

P-B5c (P-5c) Medium hard carbonaceous argillaceous micritic limestone, gradational contact below, sharp above, persistent throughout outcrop, variable in thickness. 3-6 cm.

Color: Weathers medium gray (N5), unweathered dark gray (N3).

Bedding: One bed splitting into two in places, bedding surfaces are grayish black (N2) mottled pale yellowish brown

(10YR6/2), distinguished from unit above and below by being less resistant to weathering, uneven fracture upper surface uneven, fossils weather in relief.

Composition: Micritic calcite cement, carbonaceous, 5-15% mud estimated, selenite crystals (less than 0.1 cm. long) on bedding surfaces, some pyritized fossils.

Fossils: 10-20% of weathered surface appears to be fossil fragments, on a broken surface less than 5% of area is fossils, Crurithyris (60-80%, generally with pedicle valve down), unidentifiable brachiopod fragments (second in abundance greater than 10% of fossils), Neochonetes, Hystriculina, Derbyia, ramose Ectoprocts and productid spines.

Joints: N 71°E, 75°N, S 17°E, 47°W.

P-B6 (P-6) Soft calcareous mudstone, sharp contact below and above, persistent throughout outcrop. 20 cm.

Color: Weathers medium light gray, unweathered dark gray (N3).

Bedding: Unweathered, blocky to flaky, weathers fissle to crumbly, distinguished from unit below and above by being less resistant to weathering (forms slope), lower 4 cm. more blocky with upper part more fissle.

Composition: Clay and silt grains with silt dominant, calcareous, selenite crystals between bedding planes and in fractures, iron oxide staining in possible burrow fillings.

Fossils: Fossils weather out easily, most are well preserved, upper part of bed appears as carbonate filled burrows, Crurithyris most abundant fossil concentrated in the lower 5 cm. decreasing upwards (pedicle valve up and/or down and most are articulated); Neochonetes most abundant fossil above lower 5 cm. (all observed were disarticulated oriented parallel to bedding and ranged in size from less than 1 cm. to 3 cm. in width); crinoid calyx plates, crinoid columnals, Reticulatia (non-life position i.e. pedicle valve up) and productid spines were also observed.

Joints: None observed.

P-B7a (P-7a) Hard micritic limestone, sharp lower contact, gradational upper one, persistent throughout outcrop. 12 cm.

Color: Weathers pale grayish orange pink (5YR7/1), unweathered medium gray (N5).

Bedding: One massive bed, distinguished from unit above and below by being more resistant to weathering (ledge former), weathered surface is hummocky, fracture is uneven with sharp edges, fossils weather in slight relief, parting plane 3 cm. from top.

Composition: Micritic calcite cement with patches of sparry calcite, sparry calcite fillings of some fossils, selenite crystals on joint and parting surfaces giving them a glazed appearance.

Fossils: Less than 5% of surface is fossil debris, fish debris and fragments of Orbiculoidea in lower part, fish debris disappears upward and Orbiculoidea fragments decrease, Hystriculina, next in abundance, (most in a hydrodynamically stable position i.e. pedicle valve up) crinoid debris present throughout the unit with a few fusulinids, a trilobite pygidium (Ditomopyge?), a Rhipidomella and burrows up to 3-4 cm. in diameter in the lower part.

Joints: Well defined N 72° E, 90°; S 22° E, 88° W.

P-B7b (P-7b) Soft argillaceous micritic limestone, gradational contacts below and above, persistent throughout outcrop. 10 cm.

Color: Weather dark gray (N3), unweathered grayish black (N2).

Bedding: Flaky to fissle, weathers fissle, distinguished from unit below and above by being less resistant to weathering.

Composition: Silt and clay size grains with more clay, carbonaceous, selenite crystals on bedding surfaces, some fossils pyritized and filled with iron oxide.

Fossils: Crurithyris (pedicle valve up and/or down, mostly articulated 95% of all fossils, most abundant in middle of unit), Lingula (oriented parallel to bedding), Hystriculina (non-life position i.e. pedicle valve up), and Wellerella (disarticulated and in hydrodynamically stable position i.e. convex up)

Joints: None observed.

P-B7c (P-7c) Medium soft argillaceous carbonaceous micritic limestone, contact gradational below and sharp above, persistent throughout outcrop. 5 cm.

Color: Weathers medium light gray (N6), unweathered dark gray (N3) mottled grayish orange pink (5YR7/2).

Bedding: One bed, blocky, uneven fracture, distinguished from unit above and below by being more resistant to weathering, more well cemented than underlying unit, weathers with uneven surface along joints, some upper bedding surfaces mottled suggesting burrowing, fossils weather in moderate relief.

Composition: Micritic calcite cement with 15+% clay and silt, carbonaceous, glaze of gypsum covering joint and bedding surfaces.

Fossils: 5% of rock, Crurithyris (pedicle valve up and/or down, most abundant fossil), Hystriculina (in lower part), Orbiculoidea, Wellerella (disarticulated), Derbyia (disarticulated), Reticulatia, Linoproductus (hydrodynamically stable position i.e. pedicle valve up), and algae coated grains (1-2 cm. across on the top surface).

Joints: 8-10. cm. apart, N 75° E, 86° W; S 40° E, 74° S.

APPENDIX II

Mudstones and limestones were separated at approximately three centimeter intervals to examine fossils on "bedding surfaces". The following pages consist of 1) graphic sections of the five localities measured in the field showing "bedding surface" position and petrographic sampling intervals, 2) descriptions of fossils observed on these surfaces, 3) maps of the "bedding surfaces" showing location of fossils relative to each other, and 4) visual percentage of fossils recovered by washing about nine cubic centimeters of sample. For convenience of examination this washed residue was divided into four size classes and fossil percentages are tabulated in terms of these four classes. Stippled areas on the maps are areas of bioturbation, commonly burrow filling.

Fossil names are abbreviated and are listed below:

Abbreviations

Foraminiferida

fus = Fusulinids

Ectoprocts

r I = Ramose type 1
r II = Ramose type 2
r III = Ramose type 3
r IV = Ramose type 4

f I = Fenestrate type 1
f II = Fenestrate type 2

Brachiopoda

Ling = *Lingula* cf. *carbonaria*
Orb = *Orbiculoidea* cf. *missouriensis*
Pet = *Petrocrania* cf. *modesta*
Acan = *Acanthocrania* sp.
Well = *Wellerella* cf. *osagensis*
Cru = *Crurithyris* cf. *expansa*
Comp = *Composita* cf. *subtilita*

Derb = *Derbyia* cf. *crassa*
Meek = *Meckella* cf. *striatocostata*
Nech = *Neochonetes* cf. *granulifer*
Lich = *Lissochonetes* cf. *geinitzianus*
Ret = *Reticulatia* cf. *huecoensis*
Jur = *Juresania* cf. *nebrascensis*
Hyst = *Hystriculina* cf. *histricula*
Rit = *Reticulatia* cf. *huecoensis*
Lino = *Linoproductus* cf. *magnispinus*
Canc = *Cancrinella* cf. *boonensis*
Rhip = *Rhipidomella* cf. *carbonaria*
Hust = *Hustedia* cf. *mormoni*
Ptsp = *Punctospirifer* cf. *kentuckensis*
Nesp = *Neospirifer* cf. *dunbari*

brac = unidentified brachiopod
prod = productid brachiopod

Mollusca

Vol = *Volsellina?* sp.
Pter = *Pteronites* cf. *peracuta*
Pina = *Pinna?* sp.
Myl = *Myalina* sp.
Smyl = *Septimyalina* sp.
Sch = *Schizodus* sp.
Apec = *Aviculopecten* cf. *arctisulcatus*
Wilk = *Wilkingia* cf. *terminale*

uBv = unidentified bivalve

Echinodermata

crin = crinoid debris
ech = echinoid debris

Arthropoda

tril = trilobite debris
ost = ostracodes

Vertebrata

fi de = fish debris

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bur = burrows
f-pel = fecal pellets

Fossil Size

Two columns indicate fossil size in centimeters, long dem. equals longest dimension and short dem. equals shortest dimension. Both dimensions are measures in plan view.

Orientation = Orient

p = parallel to bedding
i = inclined to bedding

A slash mark (/) separates designations of bedding orientation (p or i) from these for convexity (ccu or cvu) or zooecial position (zeu or zed).

ccu = concave up
cvu = convex up
zeu = zooecia up
zed = zooecia down

Articulated = Art

If the fossil was articulated a letter was placed in this column indicating the relative amount of valve gapping (c = closed valves).

Valve = val

The letter in this column indicated which valve of the organism was observed.

r = right valve
l = left valve
b = brachial valve
p = pedicle valve
? = valve indeterminate

Fragmented = frag

An x in this column indicates that the fossil was fragmented before deep burial.

Episymbionts = epis

The generic abbreviation or specimen number from the mapped surface was placed in this column if an episymbiontic relationship was suggested (frag = fragmented episymbiont).

Type of Preservation = type pres

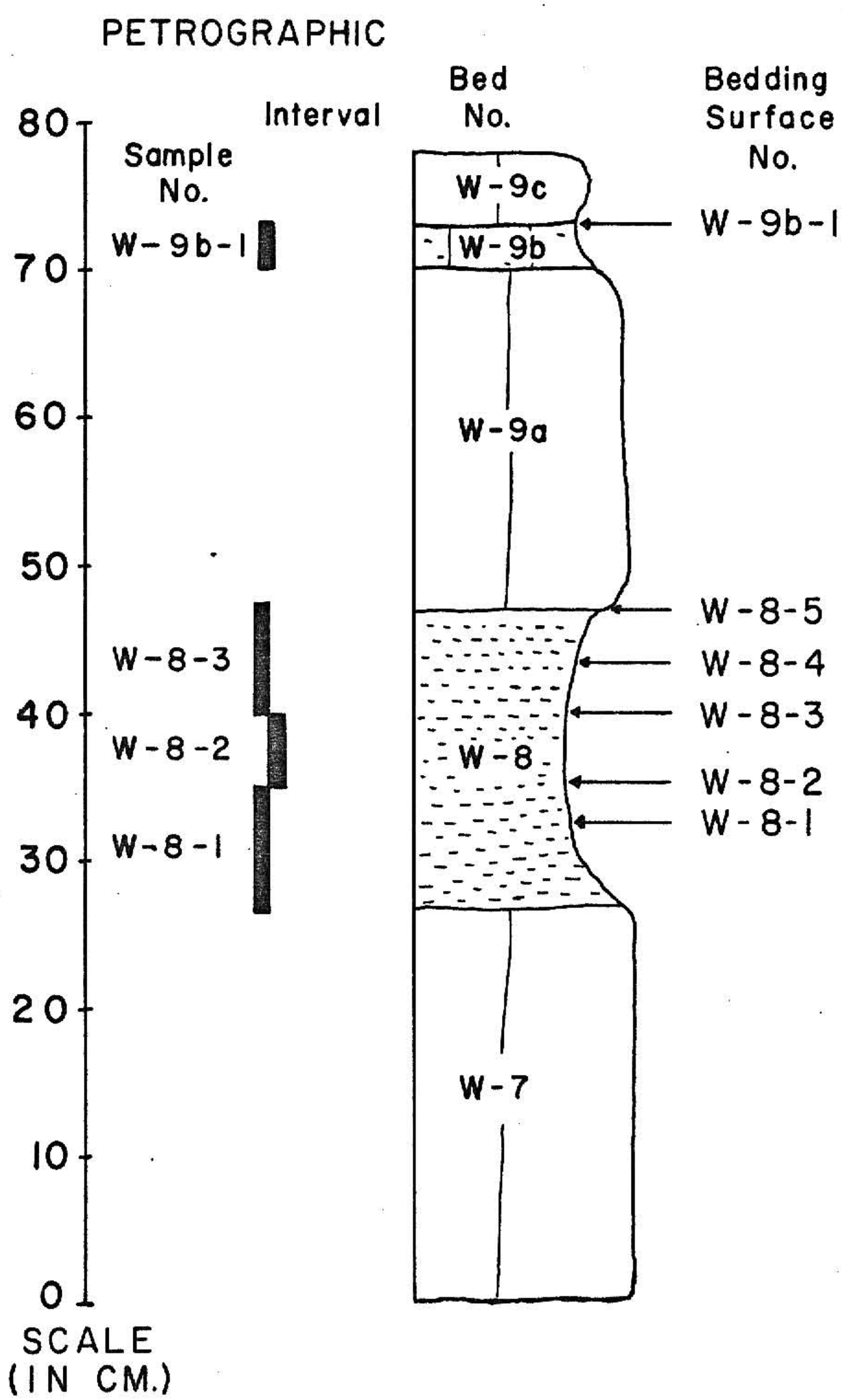
The following abbreviations are used for type of preservation

o = original or altered shell
m = molds
o&m = original or altered shell and molds
cal = more calcareous than surrounding matrix
lim = iron oxide
pyr = pyrite

Delicate Fossils = del

An x in this column indicates the size and fragile structure of the fossils was such that it could have easily been fragmented but was not.

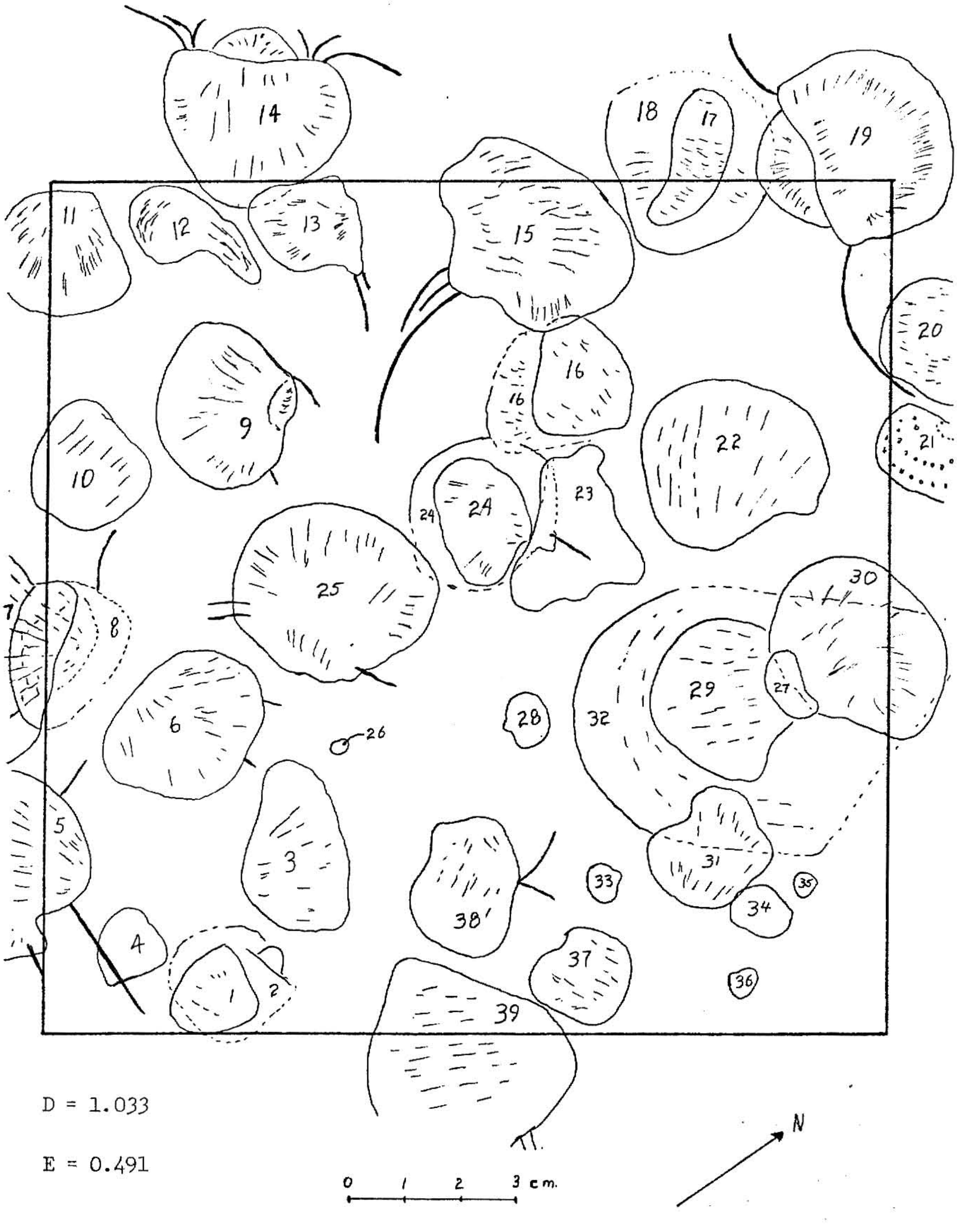
WESTMORELAND (W) SECTION



W-8-1

#	genus	long dem.	short dem.	orient	art	val	frag	epis	type pres	del
1	Lino	1.7	1.4	i/ccu		p	x		m	
2	Lino	2.2	1.7	i/ccu		p			o&m	
3	Lino	2.2	1.8	p/ccu		p			o&m	
4	uBv	1.3	0.9	p/cvu		?	x		m	
5	Lino	3.9	3.3	p/cvu		p			o	
6	Lino	2.7	2.0	p/ccu	c	b			o	
7	f II	3.5	3.0	i/				(8)	m	x
8	Lino	2.4	2.3	p/ccu.		p		(7)	o	x
9	Lino	3.0	2.6	p/ccu		p			o	x
10	Lino	2.0	1.9	p/ccu		p	x		o	
11	Lino	2.3	2.3	p/cvu		b			o&m	
12	Lino	2.7	1.5	i/ccu		p			o&m	
13	Lino	2.4	1.9	p/ccu		p			o&m	x
14	Lino	3.2	3.2	p/ccu	c	p			o	x
15	Lino	3.6	2.7	p/ccu	c	p	x		o	x
16	Lino	2.8	2.3	p/ccu		b			o	
17	Lino	2.6	1.0	p/ccu		b	x		o	
18	Lino	3.4	2.7	p/ccu		p	x		o&m	
19	Lino	3.2	3.2	p/ccu	c	p			o	x
20	Lino	2.3	2.4	p/ccu		p	x		o	
21	Jur	1.9	1.6	p/ccu		b			o	
22	Lino	3.2	3.0	i/cvu		p			o	
23	Lino	3.2	2.1	p/cvu		p	x		m	
24	Lino	2.8	2.6	p/cvu		p			o&m	x
25	Lino	3.5	2.9	p/ccu		p			o&m	x
26	Lino	0.3	0.4	p/cvu		p			o	
27	Lino	1.4	1.2	p/ccu		p			o	
28	Lino	0.9	0.8	p/cvu		p			o	
29	Lino	2.8	2.3	p/cvu	c	p			o&m	
30	Lino	3.6	2.8	p/cvu		b			o	
31	Lino	2.3	2.1	p/cvu		p			o&m	
32	Myl	6.2	4.1	p/cvu		r			o	
33	Cru	0.6	0.6	p/cvu		p			o	
34	Lino	1.3	1.1	p/cvu		b			o&m	
35	Cru	0.7	0.6	p/cvu		p			o	
36	Cru	0.4	0.4	p/cvu		p			o	
37	Lino	1.9	1.9	p/ccu		p			m	
38	Lino	2.6	1.7	p/cvu		p	x		o&m	x
39	Lino	3.5	3.2	pcvu		p			o&m	x

W-8-1



D = 1.033

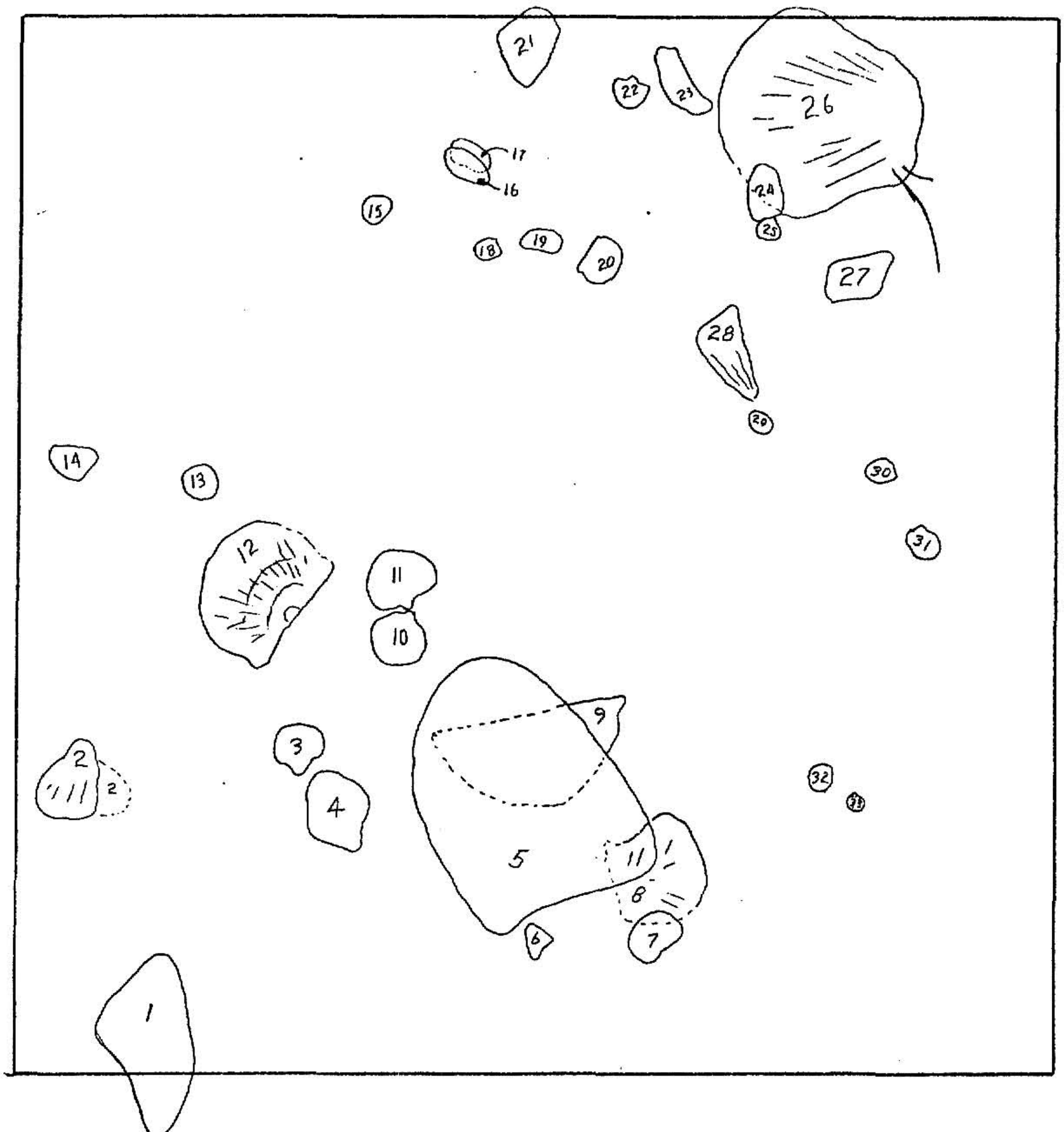
E = 0.491

MICROFOSSIL RESIDUE SAMPLE NUMBER W - 8 - 1

Taxonomic Entities	Visual Percent Retained on Mesh Sieve			
	+10	+18	+32	+60
Foraminiferids				
Ammobaculites sp.				tr
Ammodiscus sp.				
Textularids				1
Fusulinids				
Ectroprocts				
Ramose 1	3	1		
Ramose 2	5	2	tr	
Ramose 3				
Fenestrate 1			tr	tr
Fenestrate 2	3	1	tr	
Brachiopods				
Inarticulate				
Lingula sp.				
Orbiculoidea sp.				
Petrocrania sp.				
Articulate				
Wellerella sp.				
Crurithyris sp.	30	20	5	2
Derbyia sp.				
Meekella sp.				
Neochonetes sp.	1	tr	tr	
Lissochonetes sp.				
Reticulatia sp.				
Rhipidomella sp.				
Hustedia sp.	5	tr		
Productid fragments	20	15	5	5
Brachiopod fragments		30	15	15
Molluscs				
Bivalve fragments				
Myalinid fragments				
Gastropods				
Loxonematids			tr	tr
Arthropods				
Smooth ostracodes		tr	2	5
Ornamented astrocodes				tr
Trilobite debris			tr	
Barnacle plates				
Echinoderms				
Crinoid debris	tr	tr	2	1
Echinoid debris	1	1		
Ophiuroid? ossicles		tr		
Holothurian sieve plates				tr
Fish debris				tr
Conodonts				
Burrow fillings		2	1	
Worm tubes				
Matrix and unidentified fragments	32	28	69	65

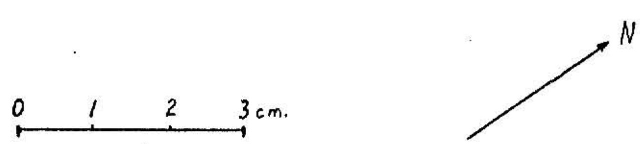
#	genus	long dem.	short dem.	orient	art	val	frag	epis	type pres	del
1	Lino	2.0	1.1	p/		p?	x		m&o	
2	Apec	1.8	1.3	i/cvu		?			m	
3	Lino	0.8	0.7	p/		?	x		m	
4	Lino	1.1	0.7	p/		?	x		m&o	
5	Ret	3.6	2.6	p/ccu		p			o	
6	Cru	0.7	0.4	i/ccu		p	x		m&o	
7	Cru	1.0	0.7	i/cvu		b			m&o	
8	Apec	1.4	1.3	i/ccu		?	x		m&o	
9	Nech	2.9	1.5	p/ccu		p			o	
10	Cru	0.9	0.8	i/cvu		p			o	
11	Cru	1.0	0.9	p/cvu	c	p			o	
12	Lino	1.8	1.6	p/cvu		b			m&o	
13	Cru	0.7	0.6	i/ccu	c	b			o	
14	Cru	0.6	0.4	i/ccu		b	x		o	
15	Cru	0.4	0.3	p/cvu		b			o	
16	Cru	0.7	0.5	i/ccu		b			o	
17	Cru	0.7	0.4	i/ccu		b			o	
18	Cru	0.4	0.3	p/ccu		b			o	
19	Cru	0.5	0.4	p/ccu		b			o	
20	prod	0.6	0.5	p/cvu		b			m	
21	Lino	0.7	0.6	i/cvu		p	x		o	
22	Cru	0.5	0.4	p/cvu		b			m	
23	Lino	1.1	0.3	p/		?	x		m	
24	Nech	0.6	0.4	p/cvu		?	x		m	
25	Lino	0.3	0.3	p/cvu		?	x		m&o	
26	Lino	3.2	2.8	p/cvu		p			m&o	
27	Lino	1.0	0.5	p/		?	x		m	
28	Lino	1.3	0.5	p/		?	x		m	
29	Cru	0.3	0.2	i/		p	x		o	
30	Cru	0.3	0.3	i/		p			o	
31	Cru	0.6	0.4	p/cvu		b			m	
32	Cru	0.3	0.3	p/cvu		p			o	
33	bur	0.2		i/					pyr	

W-8-2



D = 1.628

E = 0.784

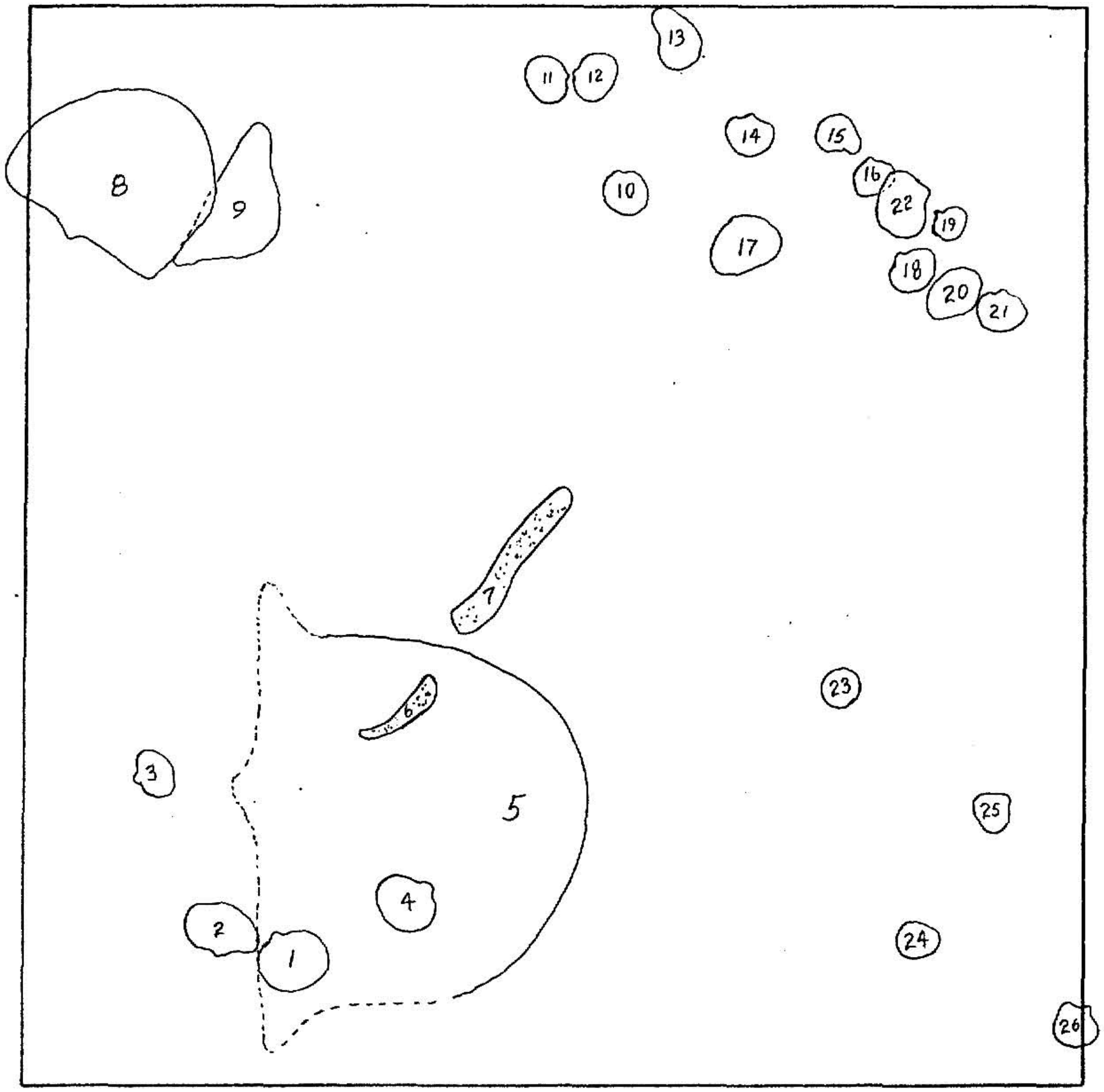


MICROFOSSIL RESIDUE SAMPLE NUMBER W - 8 - 2

Taxonomic Entities	Visual Percent Retained on Mesh Sieve +10	+18	+32	+60
Foraminiferids				
Ammobaculites sp.				
Ammodiscus sp.				
Textularids				
Fusulinids				
Ectoprocts				
Ramose 1				
Ramose 2				
Ramose 3		2	1	
Fenestrate 1				
Fenestrate 2				
Brachiopods				
Inarticulate				
Lingula sp.				
Orbiculoidea sp.				
Petrocrania sp.				
Articulate				
Wellerella sp.				
Crurithyris sp.	30	30	5	tr
Derbyia sp.				
Meekella sp.				
Neochonetes sp.				
Lissochonetes sp.				
Reticulatia sp.				
Rhipidomella sp.				
Hustedia sp.				
Productid fragments	50	35	15	10
Brachiopod fragments			10	5
Molluscs				
Bivalve fragments				
Myalinid fragments				
Gastropods				
Loxonematids				
Arthropods				
Smooth ostracodes				5
Ornamented ostracodes				
Trilobite debris				
Barnacle plates				
Echinoderms				
Crinoid debris				tr
Echinoid debris			tr	
Ophiuroid? ossicles				
Holothurian sieve plates				
Fish debris				
Conodonts				
Burrow fillings				
Worm tubes				
Matrix and unidentified fragments	20	33	69	80

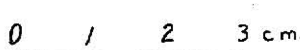
#	genus	long dem.	short dem.	orient	art	val	frag	epis	type pres	del
1	Cru	0.9	0.8	p/cvu		p			o	
2	Nech	1.0	0.6	p/cvu		b	x		o	
3	Cru	0.9	0.8	p/ccu		p			o	
4	Cru	0.8	0.6	i/ccu		b			o	
5	Ret	5.8	4.6	p/ccu	c	b			o	
6	bur	1.5	0.2	p/					pyr	
7	bur	2.2	0.2	i/					pyr	
8	Ret	3.2	2.5	p/ccu		b			m	
9	Nech	2.4	1.2	p/cvu		p			o	
10	Cru	0.8	0.7	p/cvu		p			o	
11	Cru	0.7	0.5	p/cvu		p			o	
12	Cru	0.8	0.6	p/cvu		?	x		o	
13	Cru	0.8	0.7	i/cvu		p			o	
14	Cru	0.7	0.6	p/ccu		p			o	
15	Cru	0.6	0.5	p/cvu		p			o	
16	Cru	0.6	0.6	i/cvu		p			m&o	
17	Cru	0.9	0.7	i/ccu		b			m	
18	Cru	0.8	0.7	p/cvu		p			o	
19	Cru	0.6	0.6	i/cvu		p			o	
20	Cru	0.9	0.6	p/cvu		b			o	
21	Cru	0.9	0.8	p/cvu		p			o	
22	Cru	1.0	0.8	i/ccu		p			o	
23	Cru	0.5	0.4	p/cvu		p			m	
24	Cru	0.6	0.7	p/cvu		p			m&o	
25	Cru	0.5	0.4	p/cvu		p			m	
26	Cru	0.6	0.5	p/cvu		p			o	

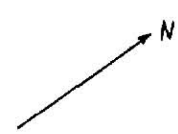
W-8-3



D = 0.595

E = 0.578



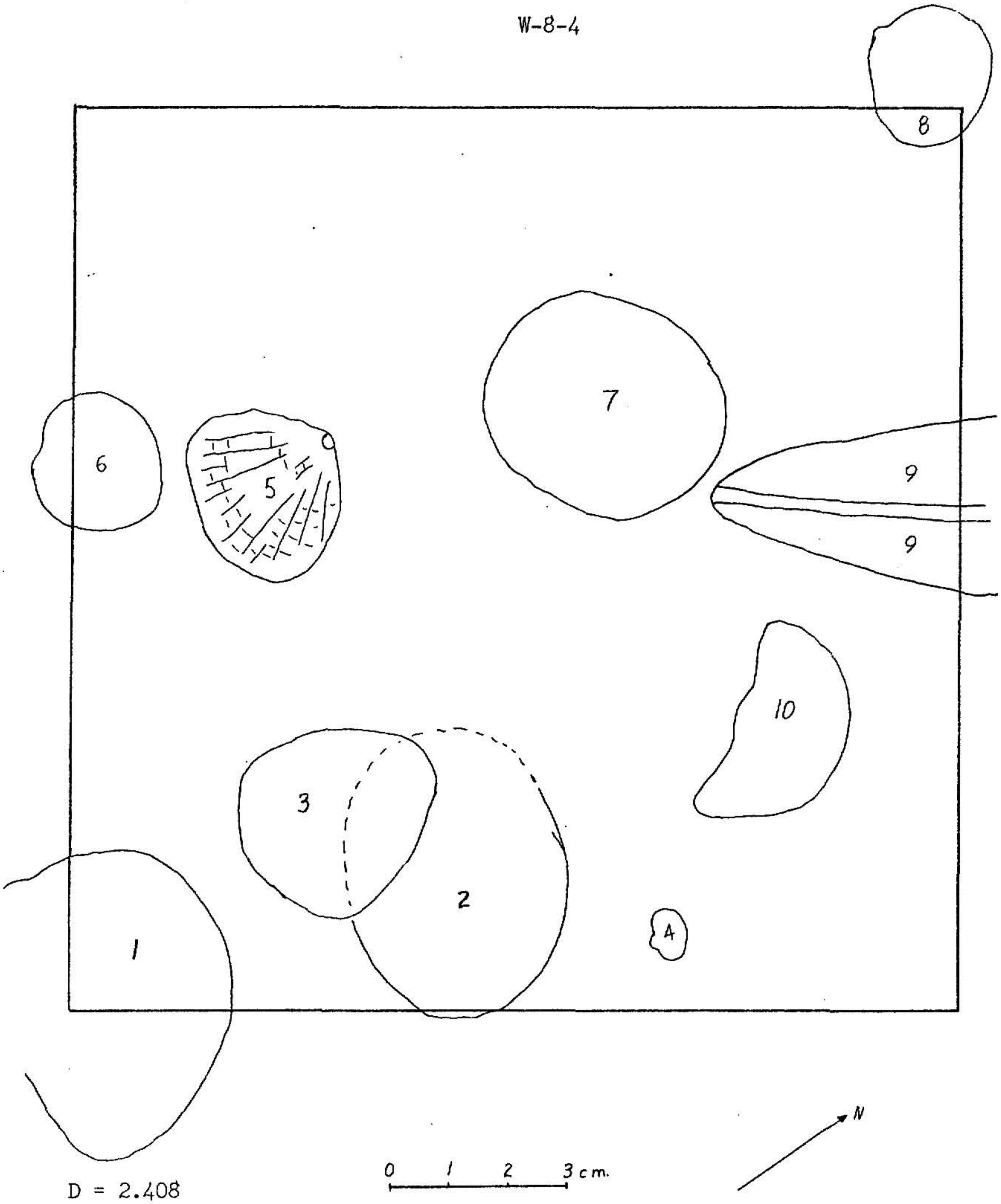


MICROFOSSIL RESIDUE SAMPLE NUMBER W - 8 - 3

Taxonomic Entities	Visual Percent Retained on Mesh Sieve			
	+10	+18	+32	+60
Foraminiferids				
Ammobaculites sp.				
Ammodiscus sp.				
Textularids				
Fusulinids				
Ectoprocts				
Ramose 1		5		
Ramose 2			1	
Ramose 3	5			
Fenestrate 1				
Fenestrate 2		5	1	
Brachiopods				
Inarticulate				
Lingula sp.				
Orbiculoidea sp.				
Petrocrania sp.				
Articulate				
Wellerella sp.		tr		
Crurithyris sp.	34	25	20	5
Derbyia sp.				
Meekella sp.				
Neochonetes sp.	7	tr	tr	
Lissochonetes sp.				
Reticulatia sp.				
Rhipidomella sp.				
Hustedia sp.				
Productid fragments	34	25	30	20
Brachiopod fragments		20	20	20
Molluscs				
Bivalve fragments				
Myalinid fragments				
Gastropods				
Loxonematids				
Arthropods				
Smooth ostracodes				1
Ornamented ostracodes				tr
Trilobite debris				
Barnacle plates		tr	tr	tr
Echinoderms				
Crinoid debris			5	5
Echinoid debris			tr	
Ophiuroid? ossicles				
Holothurian sieve plates				tr
Fish debris				
Conodonts				
Burrow fillings				
Worm tubes				
Matrix and unidentified fragments	20	20	23	49

#	genus	long dem.	short dem.	orient	art	val	frag	epis	type pres	del
1	Ret	5.6	4.3	p/cvu		b			o	
2	Ret	5.8	4.6	p/cvu		b			o	
3	Jur	3.2	2.8	p/cvu		p			m&o	
4	Cru	0.8	0.7	p/ccu	c	p			o	
5	f II	3.4	3.2	i/zeu					o	x
6	Ret	2.3	1.4	i/cvu		b			m&o	
7	Ret	3.6	3.4	p/cvu		p			m	
8	Ret	2.7	2.0	p/ccu		p	x		o	
9	Wilk	7.6	2.4	i/cvu	c				m	
10	Nesp	3.4	2.0	p/cvu		p			o	

W-8-4



D = 2.408

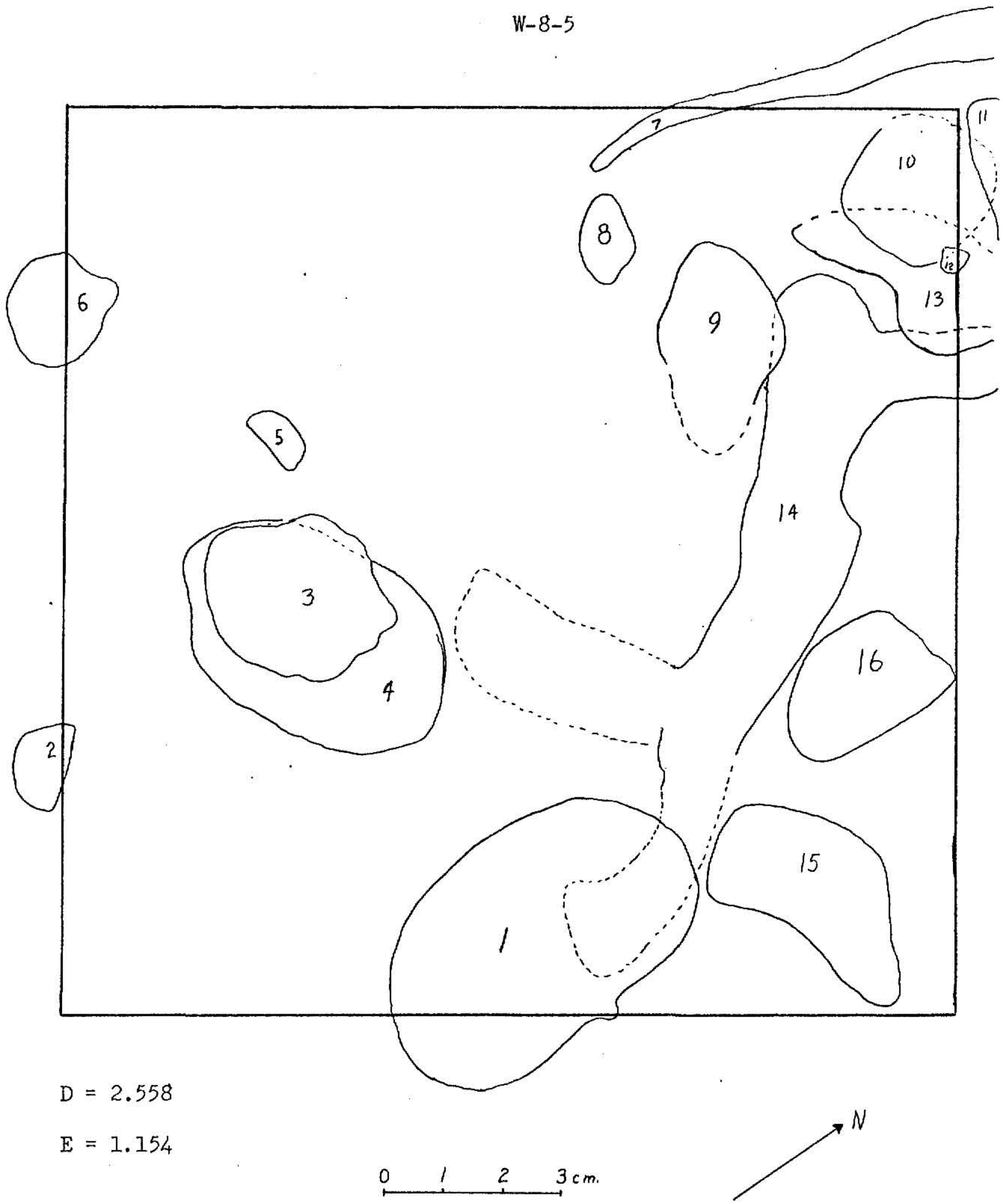
E = 1.202

MICROFOSSIL RESIDUE SAMPLE NUMBER W - 8 - 4

Taxonomic Entities	Visual Percent Retained on Mesh Sieve			
	+10	+18	+32	+60
Foraminiferids				
Ammobaculites sp.				
Ammodiscus sp.				
Textularids				
Fusulinids				
Ectoprocts				
Ramose 1				
Ramose 2	2	1	1	
Ramose 3	7			
Fenestrate 1				
Fenestrate 2	3	1	1	tr
Brachiopods				
Inarticulate				
Lingula sp.				
Orbiculoidea sp.				
Petrocrania sp.				
Articulate				
Wellerella sp.				
Crurithyris sp.	30	3	5	
Derbyia sp.				
Meekella sp.				
Neochonetes sp.	20	tr	tr	
Lissochonetes sp.				
Reticulatia sp.				
Rhipidomella sp.				
Hustedia sp.	3	tr	tr	tr
Productid fragments	25	5	3	5
Brachiopod fragments	9	80	73	40
Molluscs				
Bivalve fragments				
Myalinid fragments				
Gastropods				
Loxonematids				
Arthropods				
Smooth ostracodes			tr	5
Ornamented ostracodes				tr
Trilobite debris				
Barnacle plates				
Echinoderms				
Crinoid debris	1		2	1
Echinoid debris		tr	tr	
Ophiuroid? ossicles				
Holothurian sieve plates				
Fish debris				
Conodonts				
Burrow fillings				
Worm tubes				
Matrix and unidentified fragments		10	15	49

#	genus	long dem.	short dem.	orient	art	val	frag	epis	type pres	del
1	Ret	5.2	3.5	p/cvu		b			o	
2	Myl	1.4	1.2	p/cvu		?	x		o&m	
3	f II	3.3	2.7	p/zeu					o	x
4	Ret	4.2	3.7	p/ccu		p			o	
5	Derb	1.3	0.8	i/					m	
6	f II	2.0	1.9	p/zed					o	x
7	r III	9.8	1.4	i/					o	x
8	uBv	1.3	0.7	i/		?	x		o	
9	f II	3.4	2.2	p/zeu					o	x
10	Ret	2.7	2.7	p/ccu	c	b			o	
11	f II	2.3	1.7	p/zed			x		o	x
12	Rhip	0.4	0.4	p/ccu					m	
13	r III	8.2	2.6	i/					o	x
14	r III	15.0	2.0	i/				pet r I	o	x
15	r III	4.2	1.0	p/					o	x
16	Jur	2.8	1.9	p/ccu	c				o	x

W-8-5



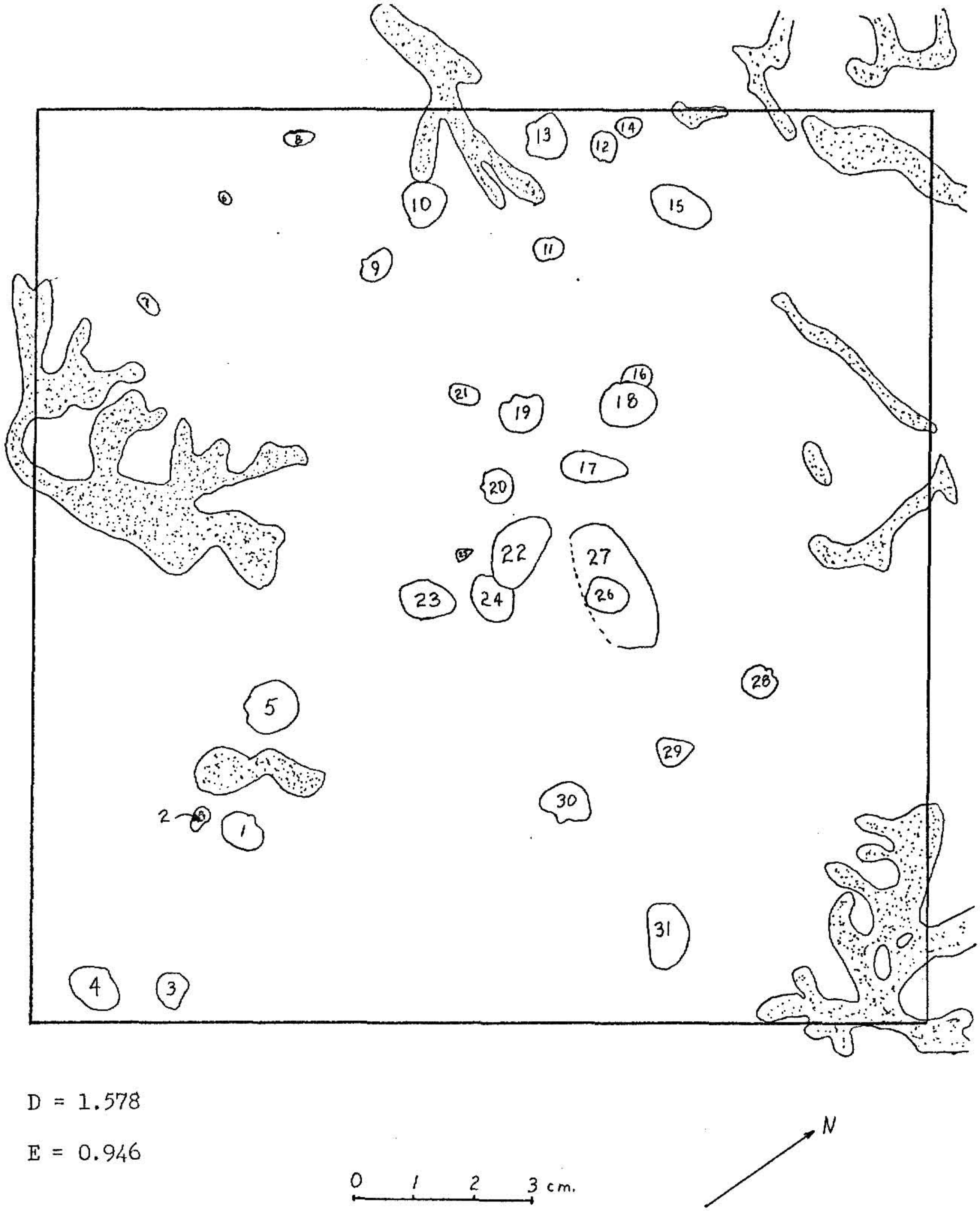
D = 2.558

E = 1.154

MICROFOSSIL RESIDUE SAMPLE NUMBER W - 8 - 5

Taxonomic Entities	Visual Percent Retained on Mesh Sieve			
	+10	+18	+32	+60
Foraminiferids				
Ammobaculites sp.				
Ammodiscus sp.				
Textularids				
Fusulinids				
Ectoprocts				
Ramose 1		2		
Ramose 2	1			
Ramose 3	1	1		
Fenestrate 1				
Fenestrate 2	15	5	tr	
Brachiopods				
Inarticulate				
Lingula sp.				
Orbiculoidea sp.				
Petrocrania sp.	1	tr		
Articulate				
Wellerella sp.				
Crurithyris sp.	3	1		
Derbyia sp.				
Meekella sp.				
Neochonetes sp.	1			
Lissochonetes sp.				
Reticulatia sp.				
Rhipidomella sp.				
Hustedia sp.		1		
Productid fragments	10	3	15	10
Brachiopod fragments		15	30	5
Molluscs				
Bivalve fragments	1	tr		tr
Myalinid fragments				
Gastropods				
Loxonematids				
Arthropods				
Smooth ostracodes				1
Ornamented ostracodes				tr
Trilobite debris		tr		
Barnacle plates				
Echinoderms				
Crinoid debris	5	1	1	1
Echinoid debris		tr	tr	tr
Ophiuroid? ossicles		tr		
Holothurian sieve plates				
Fish debris				tr
Conodonts				
Burrow fillings				
Worm tubes				
Matrix and unidentified fragments	62	71	54	82

#	genus	long dem.	short dem.	orient	art	val	frag	epis	pres	del
1	Cru	0.7	0.6	p/ccu		p			o	
2	Orb	0.4	0.2	i/		?	x		o	
3	Cru	0.6	0.4	p/cvu		b	x		o	
4	Cru	0.7	0.6	p/ccu		p			m	
5	Cru	0.8	0.8	p/cvu		p			o	
6	Ling	0.2	0.1	p/cvu		?			o	
7	Orb	0.4	0.2	p/cvu		?	x		o	
8	Ling	0.4	0.2	p/cvu		?			o	
9	Cru	0.6	0.5	p/cvu		p			o	
10	Cru	0.8	0.7	p/ccu		p			o	
11	Orb	0.5	0.4	i/ccu		p			m&o	
12	Cru	0.8	0.7	p/cvu		p			o	
13	Cru	0.8	0.7	p/ccu		p			m	
14	Ling	0.5	0.3	p/ccu		?			o	
15	Ling	1.1	0.5	p/ccu		?			m&o	
16	Cru	0.5	0.3	p/cvu		?			o	
17	Vol	1.3	0.7	p/ccu		r			m	
18	Cru	0.9	0.7	p/cvu		p			o	
19	Cru	0.8	0.6	p/cvu		p			o	
20	Cru	0.6	0.6	p/cvu		p			o	
21	Ling	0.3	0.2	p/cvu		?			o	
22	Ling	1.4	0.8	p/ccu		?			m&o	
23	Ling	1.0	0.6	p/cvu		?			m&o	
24	Cru	0.8	0.7	p/ccu		p			o	
25	Ling	0.2	0.2	p/cvu		?	x		o	
26	brac	0.7	0.4	p/ccu		?	x		o	
27	uBv	1.9	1.1	p/cvu		?	x		m	
28	Cru	0.5	0.5	p/cvu		p			o	
29	Orb	0.6	0.5	p/cvu		?	x		o	
30	Cru	0.7	0.7	p/cvu		p			o	
31	Ling	1.2	0.6	p/ccu		?			o	


13
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1
31
4
3
0 1 2 3 cm.
N

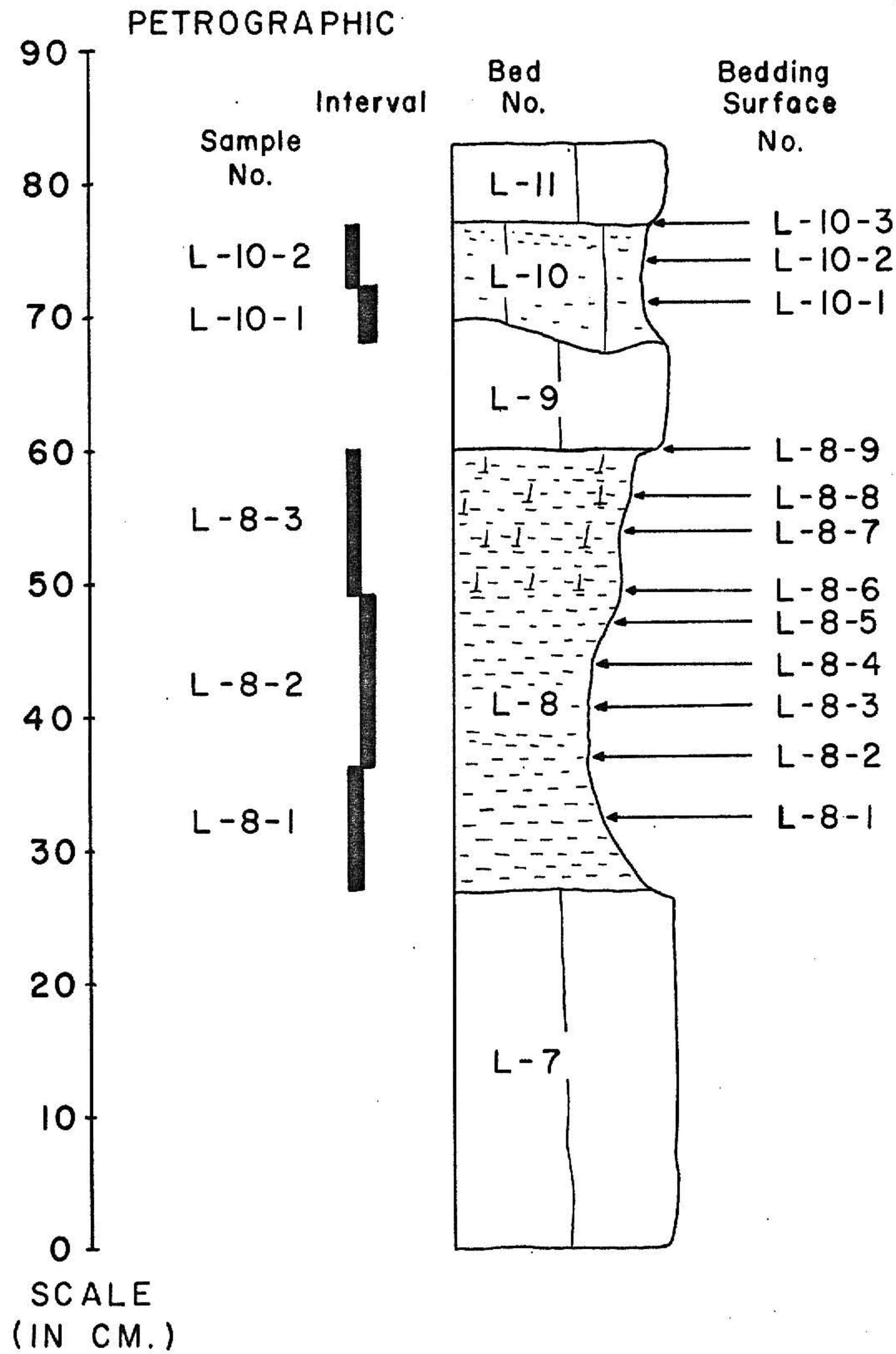
D = 1.578

E = 0.946

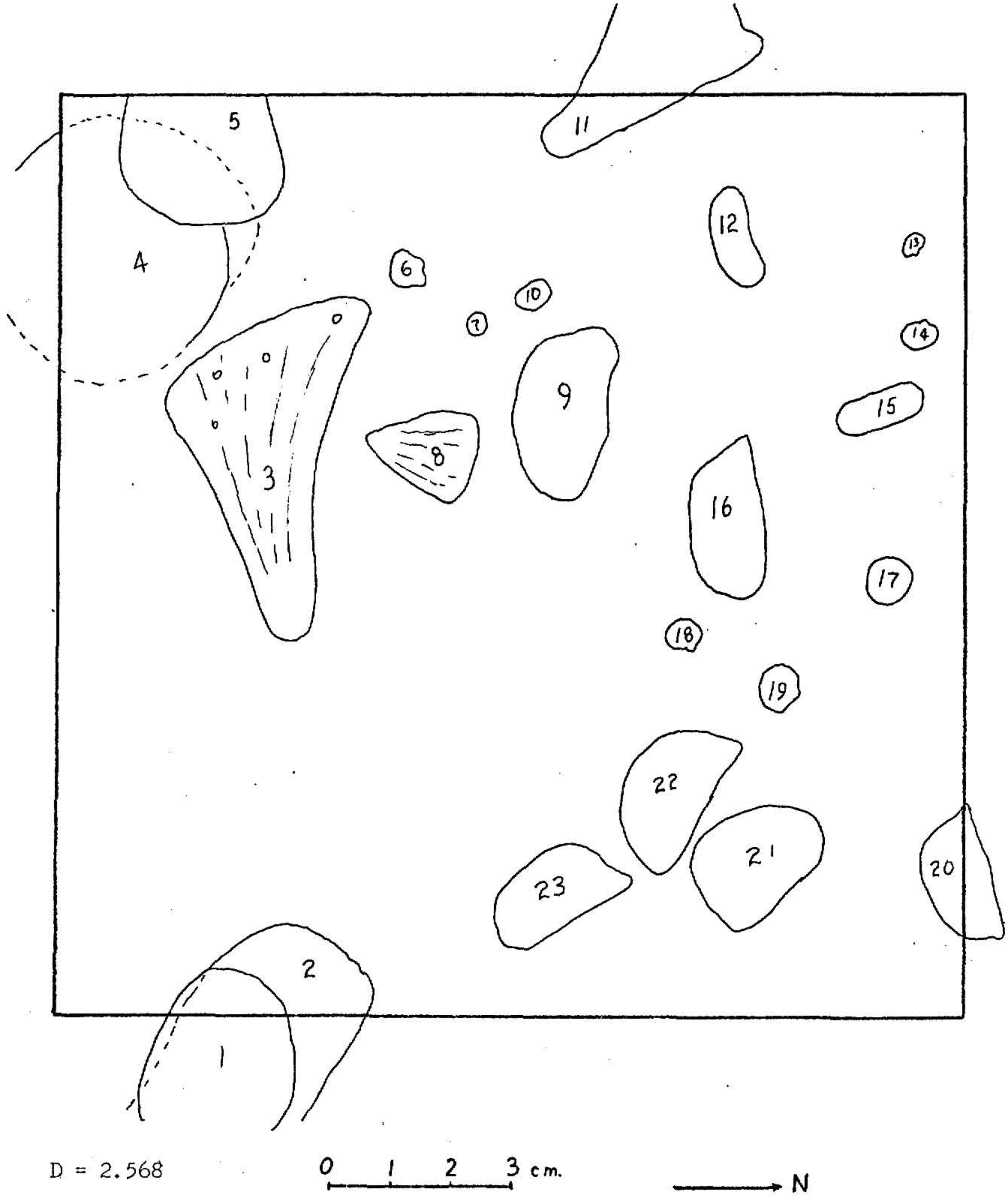
MICROFOSSIL RESIDUE — SAMPLE NUMBER W - 9b - 1

Taxonomic Entities	Visual Percent Retained on Mesh Sieve			
	+10	+18	+32	+60
Foraminiferids				
Ammobaculites sp.				1
Ammodiscus sp.				4
Textularids				
Fusulinids				
Ectoprocts				
Ramose 1				
Ramose 2				
Ramose 3				
Fenestrate 1				
Fenestrate 2				
Brachiopods				
Inarticulate				
Lingula sp.			tr	2
Orbiculoidea sp.				1
Petrocrania sp.				
Articulate				
Wellerella sp.				
Crurithyris sp.	30	20	1	
Derbyia sp.				
Meekella sp.				
Neochonetes sp.				
Lissochonetes sp.				
Reticulatia sp.				
Rhipidomella sp.		tr	tr	
Hustedia sp.				
Productid fragments		tr	tr	tr
Brachiopod fragments	10	40	20	10
Molluscs				
Bivalve fragments				
Myalinid fragments				
Gastropods				
Loxonematids				
Arthropods				
Smooth ostracodes				tr
Ornamented ostracodes				
Trilobite debris				
Barnacle plates				
Echinoderms				
Crinoid debris	1	1	tr	tr
Echinoid debris				
Ophiuroid? ossicles				
Holothurian sieve plates				
Fish debris				tr
Conodonts				
Burrow fillings				
Worm tubes				
Matrix and unidentified fragments	59	39	79	82

LOUISVILLE (L) SECTION



#	genus	long dem.	short dem.	orient	art	val	frag	epis	type pres	del
1	Derb	3.1	2.6	i/cvu		b			o	
2	Myl	3.8	2.7	i/cvu		r			m	
3	Pina	5.2	3.8	i/ccu		l			m&o	
4	Ret	4.4	4.3	p/cvu		p			o	
5	prod	3.6	3.0	i/cvu		b	x		o	
6	Cru	0.7	0.6	p/cvu		p			o	
7	Cru	0.2	0.4	i/cvu		p	x		o	
8	Apec	1.6	1.2	p/		?	x		m	
9	prod	2.3	1.9	i/ccu		b			m	
10	brac	0.7	0.4	p/cvu		?	x		o	
11	Pina	4.1	2.6	p/ccu		?			m	
12	uBv	1.4	0.7	i/cvu		?	x		o	
13	Cru	0.6	0.5	i/cvu		p			o	
14	Cru	0.6	0.5	p/cvu		p			o	
15	Nech	1.9	1.0	i/		b	x		o	
16	Nech	2.8	1.4	i/cvu		p			o	
17	Pet	0.9	0.8	p/cvu		p			m	
18	Cru	0.5	0.5	i/cvu		p			o	
19	Cru	0.5	0.6	p/cvu		p	x		o	
20	Nech	2.3	1.2	p/cvu		b			o	
21	Nech	2.1	1.5	p/ccu		p			m	
22	Nech	2.7	1.4	i/cvu		p			o	
23	Nech	2.4	1.3	i/cvu		b			o	



D = 2.568

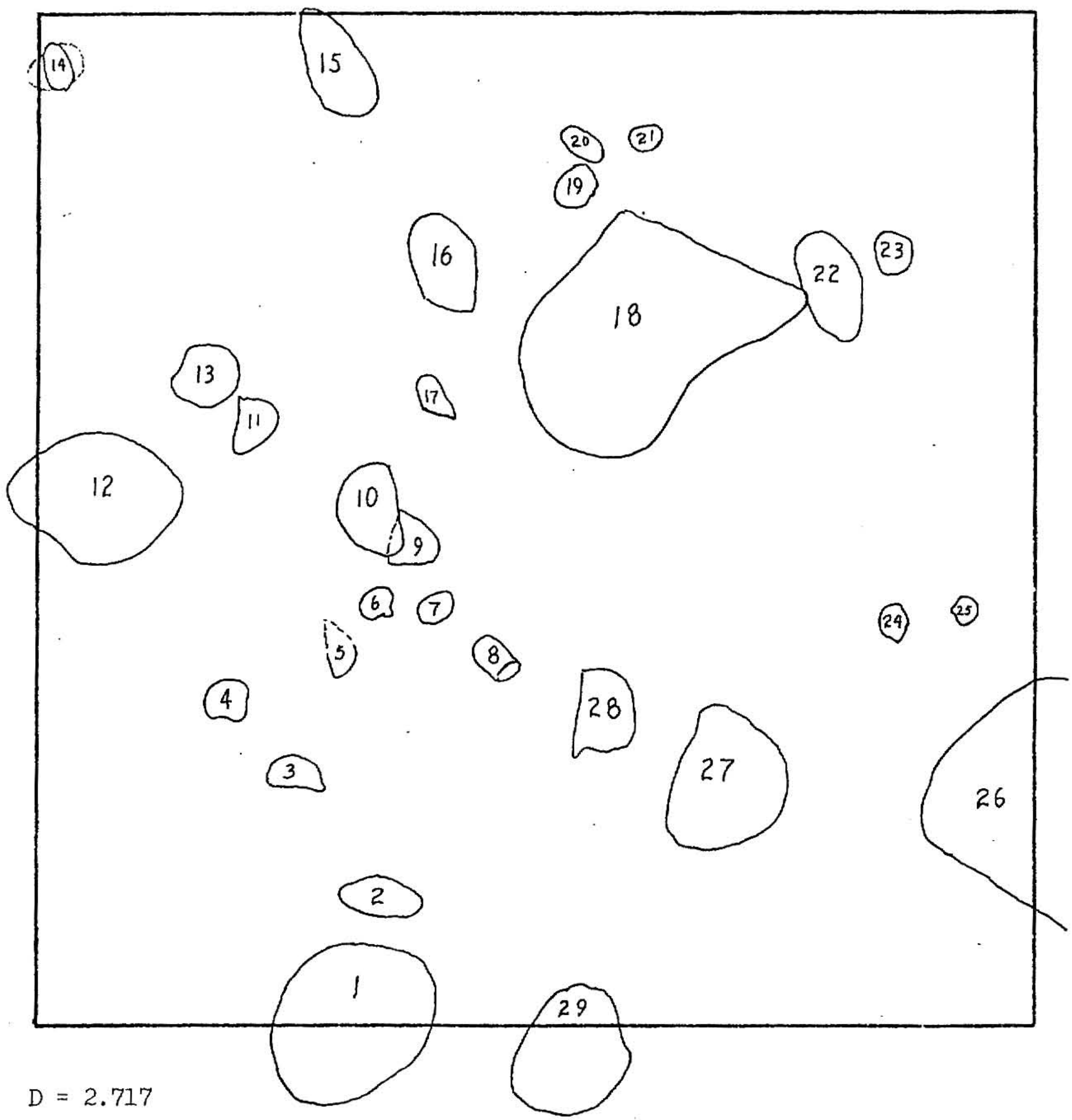
E = 1.018

MICROFOSSIL RESIDUE SAMPLE NUMBER L - 8 - 1

Taxonomic Entities	Visual Percent Retained on Mesh Sieve			
	+10	+18	+32	+60
Foraminiferids				
Ammobaculites sp.				
Ammodiscus sp.				
Textularids				tr
Fusulinids				
Ectoprocts				
Ramose 1	6	tr		
Ramose 2	4	1	tr	
Ramose 3				
Fenestrate 1				
Fenestrate 2	1	1	2	
Brachiopods				
Inarticulate				
Lingula sp.				
Orbiculoidea sp.				
Petrocrania sp.				
Articulate				
Wellerella sp.				
Crurithyris sp.	20	10	5	tr
Derbyia sp.				
Meekella sp.				
Neochonetes sp.	15	tr	tr	
Lissochonetes sp.				
Reticulatia sp.				
Rhipidomella sp.				
Neospirifer sp.	2			
Productid fragments	10	10	10	10
Brachiopod fragments	10	5	10	15
Molluscs				
Bivalve fragments	2			
Myalinid fragments				
Gastropods				
Loxonematids				
Arthropods				
Smooth ostracodes			tr	1
Ornamented ostracodes			tr	tr
Trilobite debris				
Barnacle plates				
Echinoderms				
Crinoid debris	3			
Echinoid debris	1	3	2	tr
Ophiuroid? ossicles				
Holothurian sieve plates				tr
Fish debris	1	tr	tr	tr
Conodonts				
Burrow fillings				
Worm tubes				
Matrix and unidentified fragments	25	70	80	72

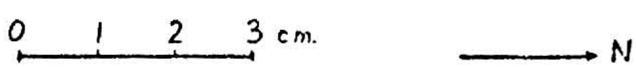
#	genus	long dem.	short dem.	orient	art	val	frag	epis	type pres	del
1	Derb	2.7	2.5	p/cvu		p			m	
2	Nech	1.2	0.6	p/ccu		p	x		m	
3	r I	0.3	0.2	p/					o	
4	crin	0.6	0.6	i/					m	
5	Nech	0.7	0.4	i/ccu		p			o	
6	Cru	0.5	0.4	p/cvu		p			o	
7	brac	0.4	0.4	p/ccu			x		m	
8	crin	0.6	0.5	i/					o	
9	Apec	0.8	0.8	p/cvu		?			m	
10	Nech	1.3	0.8	p/ccu		p			m	
11	Cru	0.9	0.6	p/		b			m	
12	Derb	2.8	2.0	i/cvu		b			m	
13	Apec	1.0	0.8	p/ccu		?			m	
14	Cru	0.6	0.5	p/cvu		p			o	
15	Jur	1.8	0.6	i/cvu		p			o	
16	Hyst	3.2	1.6	p/ccu		p			m&o	
17	Nech	1.1	0.7	p/cvu		b			m	
18	Myl	4.2	3.0	i/cvu		l			o&s	
19	Cru	0.8	0.7	p/cvu		p			o	
20	Nech	0.6	0.5	p/cvu		b	x		o	
21	Cru	0.6	0.4	p/ccu		b	x		o	
22	Nech	1.3	0.6	i/ccu		b			o	
23	Cru	0.6	0.4	p/cvu		b			o	
24	brac	0.5	0.5	p/		?	x		o	
25	Cru	0.5	0.4	p/cvu		p			o	
26	Myl	4.7	3.2	p/ccu		r			m&o	
27	Derb	1.8	1.1	p/cvu		b			m	
28	Nech	1.4	0.9	p/cvu		p	x		m	
29	Derb	2.1	1.7	p/cvu		?	x		m	

L-8-2



D = 2.717

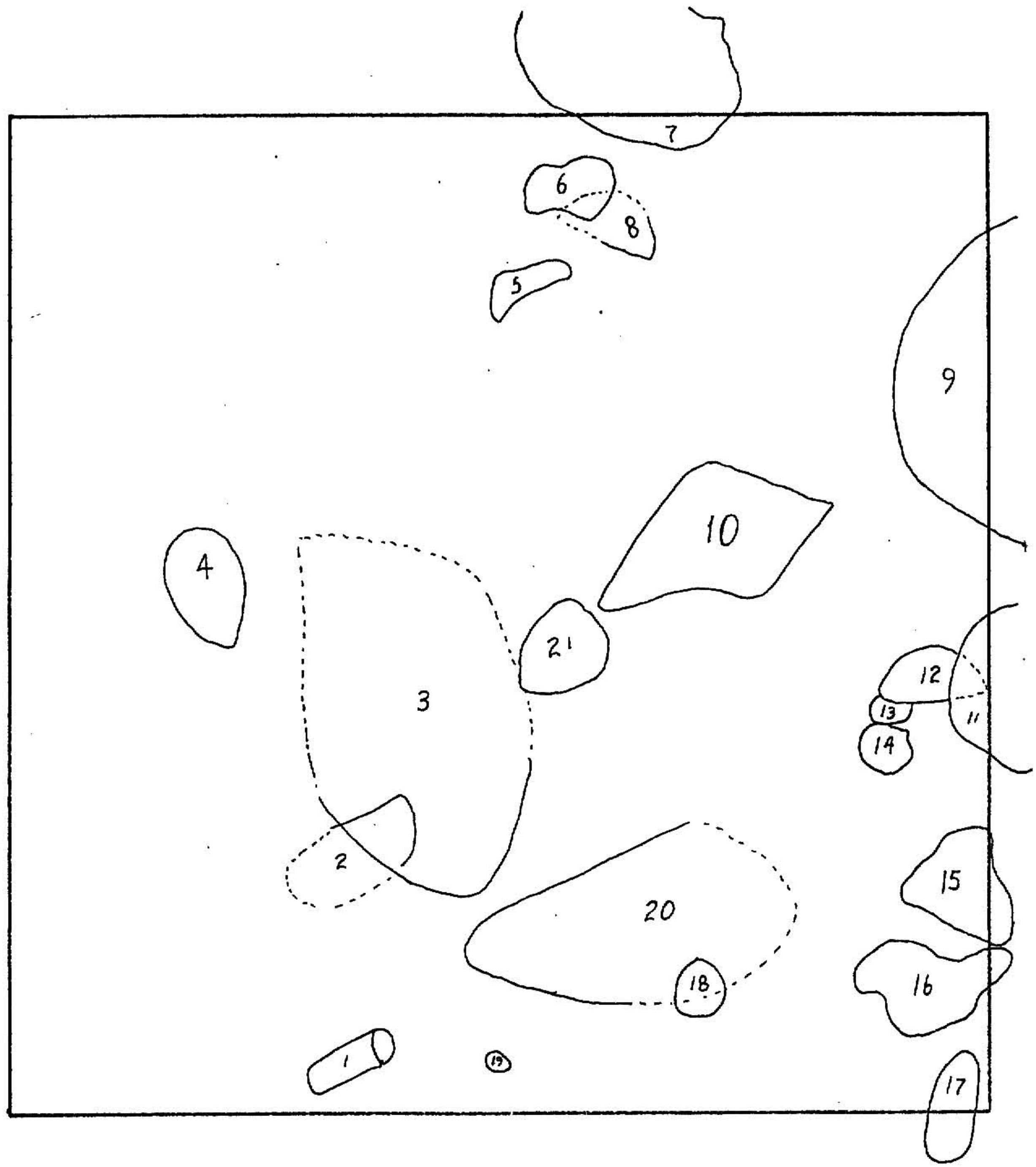
E = 0.910



MICROFOSSIL RESIDUE SAMPLE NUMBER L - 8 - 2

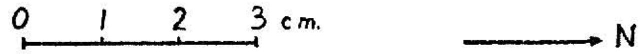
Taxonomic Entities	Visual Percent Retained on Mesh Sieve			
	+10	+18	+32	+60
Foraminiferids				
Ammobaculites sp.				
Ammodiscus sp.				
Textularids				tr
Fusulinids		tr		
Ectoprocts				
Ramose 1	5			
Ramose 2	2	tr		
Ramose 3	1			
Fenestrate 1		tr	1	1
Fenestrate 2		3	tr	
Brachiopods				
Inarticulate				
Lingula sp.				
Orbiculoidea sp.				
Petrocrania sp.				
Articulate				
Wellerella sp.				
Crurithyris sp.	15	10	7	5
Derbyia sp.				
Meekella sp.		tr		
Neochonetes sp.				
Lissochonetes sp.				
Reticulatia sp.				
Rhipidomella sp.		tr		
Hustedia sp.				
Productid fragments	20	20	25	10
Brachiopod fragments	12	30	15	20
Molluscs				
Bivalve fragments				
Myalinid fragments				
Gastropods				
Loxonematids				
Arthropods				
Smooth ostracodes			2	5
Ornamented ostracodes			tr	3
Trilobite debris			tr	tr
Barnacle plates				
Echinoderms				
Crinoid debris		2	3	3
Echinoid debris	1	4		
Ophiuroid? ossicles				
Holothurian sieve plates				tr
Fish debris				
Conodonts				
Burrow fillings				
Worm tubes				
Matrix and unidentified fragments	50	34	43	52

#	genus	long dem.	short dem.	orient	art	val	frag	epis	type pres	del
1	crin	1.5	0.7	i/					o	
2	Nech	2.8	1.6	i/ccu	c	b			o	
3	Myl	5.2	3.7	i/cvu		r	x		m&o	
4	Myl	1.9	1.2	p/cvu		l			o	
5	brac	1.0	0.6	p/		?	x		m	
6	prod	1.8	1.3	p/cvu		?	x		m&o	
7	Jur	3.6	2.6	p/ccu		p	x		o	
8	Nech	1.7	0.8	i/cvu		p			o	
9	Myl	5.6	3.5	p/cvu		r			m&o	
10	Nesp	3.2	2.3	p/cvu		p	x		o	
11	Derb	2.9	2.4	p/cvu		?			m	
12	Nech	1.6	0.8	p/ccu		p	x		o	
13	ech	0.9	0.5	p/					o	
14	Cru	0.6	0.6	p/cvu		p			o	
15	Apec	1.8	1.6	p/ccu		?	x		m	
16	Nesp	2.4	1.3	p/cvu		?	x		m	
17	Apec	1.7	1.6	p/cvu		?	x		m	
18	Cru	0.7	0.7	p/cvu	c	p			o	
19	Cru	0.5	0.4	p/cvu		p			o	
20	Myl	4.5	2.0	p/cvu		l			m	
21	Hyst	2.1	1.8	p/cvu		p			m	



D = 2.986

E - 1.224

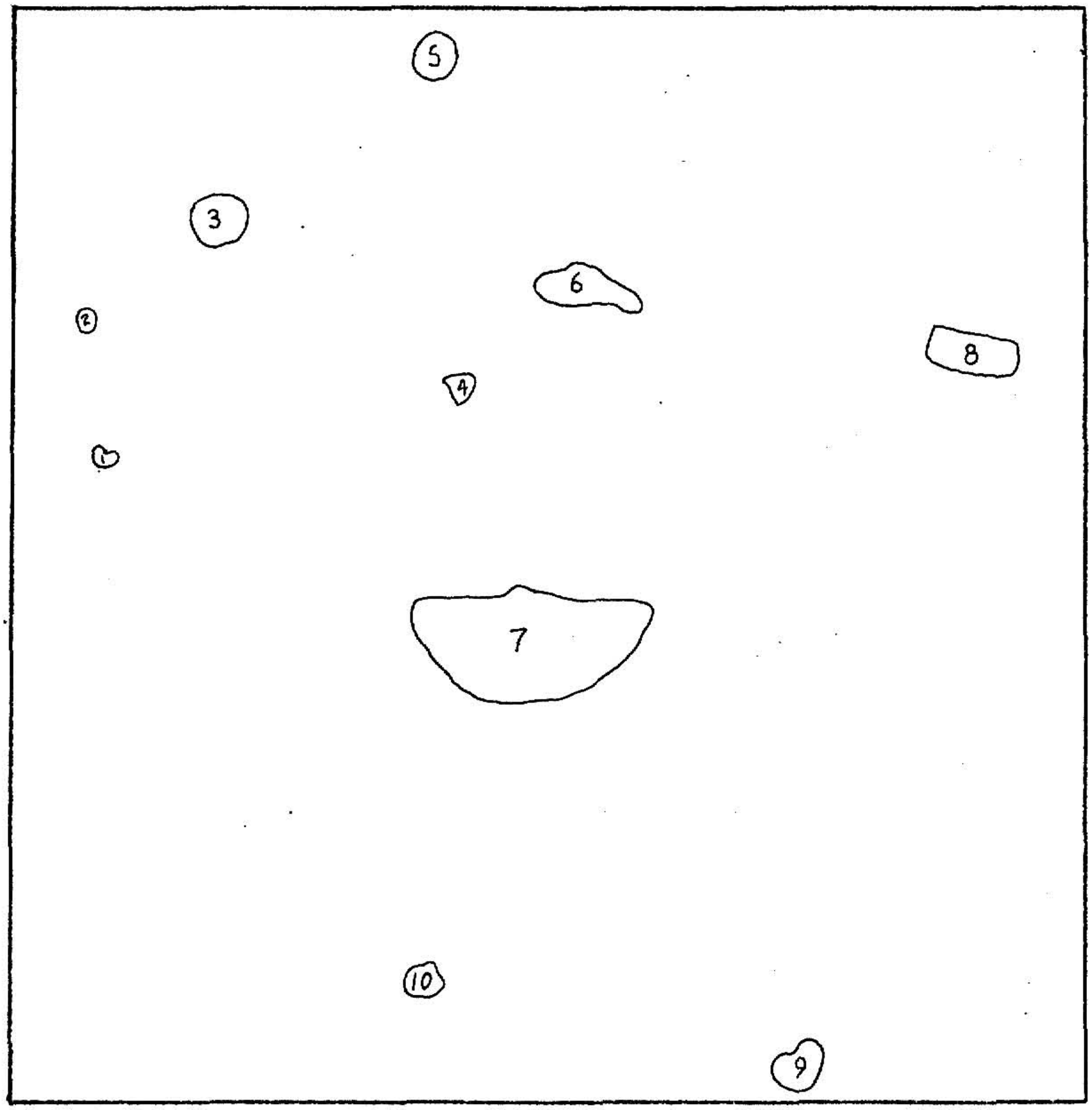


MICROFOSSIL RESIDUE SAMPLE NUMBER L - 8 - 3

Taxonomic Entities	Visual Percent Retained on Mesh Sieve			
	+10	+18	+32	+60
Foraminiferids				
Ammobaculites sp.				
Ammodiscus sp.				
Textularids				
Fusulinids				
Ectoprocts				
Ramose 1				
Ramose 2	5	7	1	tr
Ramose 3				
Fenestrate 1			1	
Fenestrate 2	5	3	10	3
Brachiopods				
Inarticulate				
Lingula sp.				
Orbiculoidea sp.				
Petrocrania sp.				
Articulate				
Wellerella sp.				
Crurithyris sp.	7	2	5	1
Derbyia sp.	3			
Meekella sp.				
Neochonetes sp.	15			
Lissochonetes sp.				
Reticulatia sp.				
Rhipidomella sp.				
Hustedia sp.	5	4	7	
Productid fragments	20	10	10	10
Brachiopod fragments	7	50	20	25
Molluscs				
Bivalve fragments	20	7	1	tr
Myalinid fragments				
Gastropods				
Loxonematids				
Arthropods				
Smooth ostracodes				5
Ornamented ostracodes				tr
Trilobite debris			tr	
Barnacle plates				
Echinoderms				
Crinoid debris	7	3	5	1
Echinoid debris		1	1	2
Ophiuroid? ossicles			tr	tr
Holothurian sieve plates				
Fish debris			tr	
Conodonts				
Burrow fillings				
Worm tubes				
Matrix and unidentified fragments	6	13	47	52

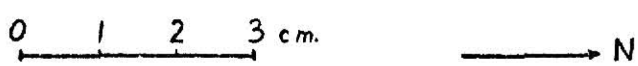
#	genus	long dem.	short dem.	orient	art	val	frag	epis	type pres	del
1	crin	0.2	0.3	p/					o	
2	Cru	0.4	0.4	p/cvu		p	x		o	
3	crin	0.7	0.2	p/					o	
4	Cru	0.4	0.3	p/cvu		p	x		o	
5	crin	0.6	0.4	i/					o	
6	Myl	1.4	0.4	p/		?	x	r I	o	
7	Nesp	3.8	2.1	i/cvu		p			o	
8	crin	1.2	0.5	i/					o	
9	Cru	0.7	0.6	i/cvu		p			o	
10	Cur	0.6	0.6	p/cvu		p			o	

L-8-4



D = 1.668

E = 1.011

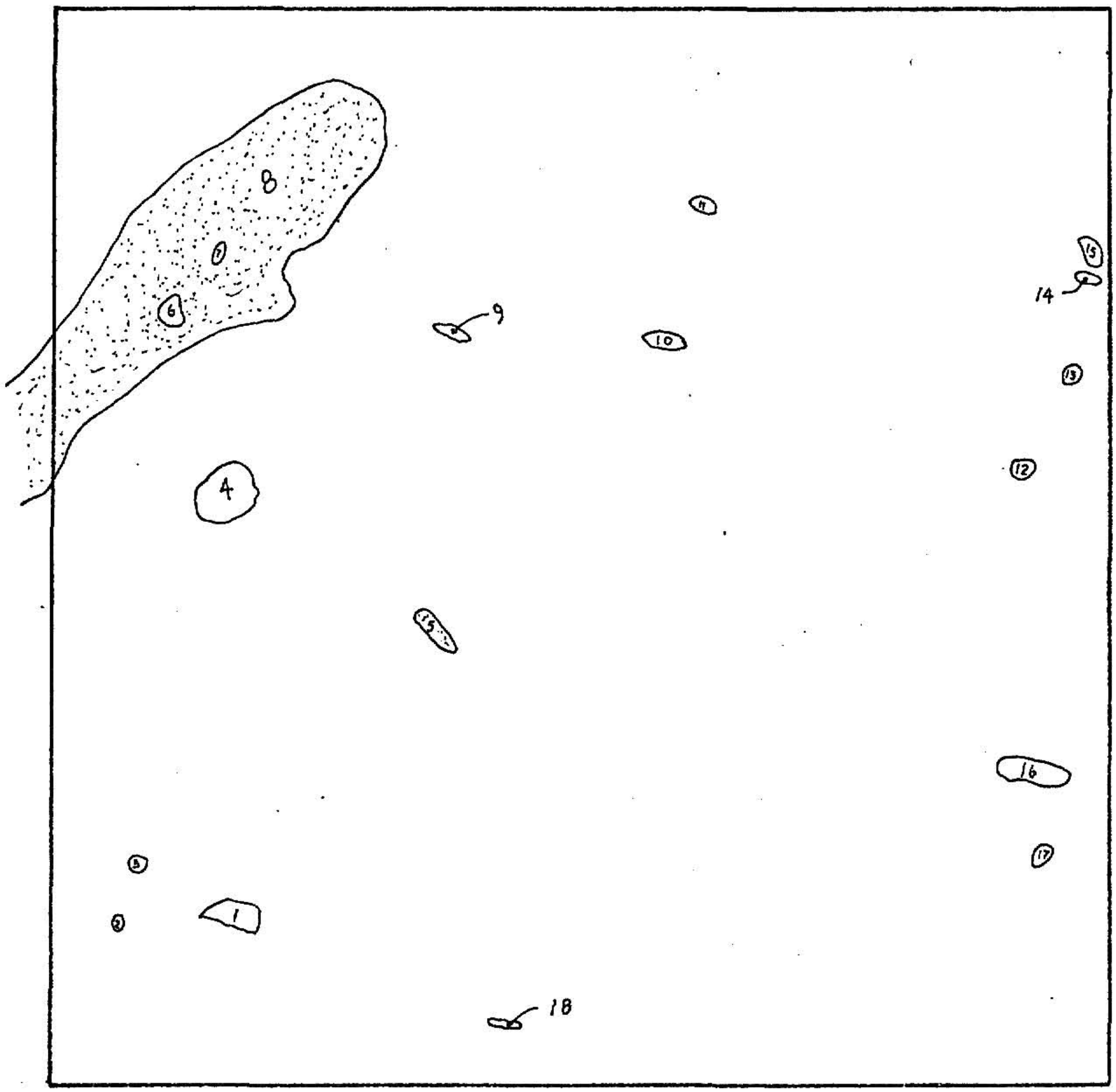


MICROFOSSIL RESIDUE — SAMPLE NUMBER L - 8 - 4

Taxonomic Entities	Visual Percent Retained on Mesh Sieve			
	+10	+18	+32	+60
Foraminiferids				
Ammobaculites sp.				
Ammodiscus sp.				
Textularids				
Fusulinids				
Ectoprocts				
Ramose 1	1			
Ramose 2	3		1	
Ramose 3				
Fenestrate 1		1	1	
Fenestrate 2		5	8	1
Brachiopods				
Inarticulate				
Lingula sp.				
Orbiculoidea sp.				
Petrocrania sp.				
Articulate				
Wellerella sp.				
Crurithyris sp.	5	5	5	1
Derbyia sp.		tr		
Meekella sp.				
Neochonetes sp.	8	tr		
Lissochonetes sp.				
Reticulatia sp.				
Rhipidomella sp.				
Hustedia sp.	3	1		
Productid fragments	30	20	25	25
Brachiopod fragments	10	35	40	20
Molluscs				
Bivalve fragments	10	35	40	20
Myalinid fragments				
Gastropods				
Loxonematids				
Arthropods				
Smooth ostracodes			tr	7
Ornamented ostracodes				1
Trilobite debris			tr	tr
Barnacle plates				
Echinoderms				
Crinoid debris	7	1	3	2
Echinoid debris	1	7	1	tr
Ophiuroid? ossicles		tr	1	tr
Holothurian sieve plates				
Fish debris				tr
Conodonts				
Burrow fillings				
Worm tubes				
Matrix and unidentified fragments	7	15	10	40

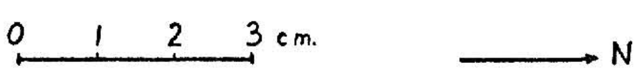
#	genus	long dem.	short dem.	orient	art	val	frag	epis	type pres	del
1	brac	0.6	0.3	p/		?	x		o	
2	brac	0.3	0.2	p/		?	x		o	
3	Cru	0.2	0.2	p/cvu		p	x		o	
4	Hust	0.8	0.8	p/cvu	c	p			o	
5	bur	0.7	0.2	p/					lim	
6	Cur	0.3	0.3	p/ccu		p	x		o	
7	brac	0.7	0.2	i/		?	x		o	
8	bur	7.8	1.8	p/				frag	cal	
9	brac	0.4	0.1	p/		?	x		o	
10	Nesp	0.6	0.5	i/cvu		p	x		o	
11	brac	0.5	0.3	i/		?	x		o	
12	brac	0.4	0.2	i/		?	x		o	
13	brac	0.3	0.2	i/		?	x		o	
14	brac	0.3	0.1	i/		?	x		o	
15	fus	0.6	0.2	p/					o	
16	Hyst	1.2	0.4	p/ccu		p	x		o	
17	brac	0.4	0.3	i/cvu		?	x		o	
18	brac	0.5	0.1	p/		?	x		o	

L-8-5



D = 2.256

E = 1.258

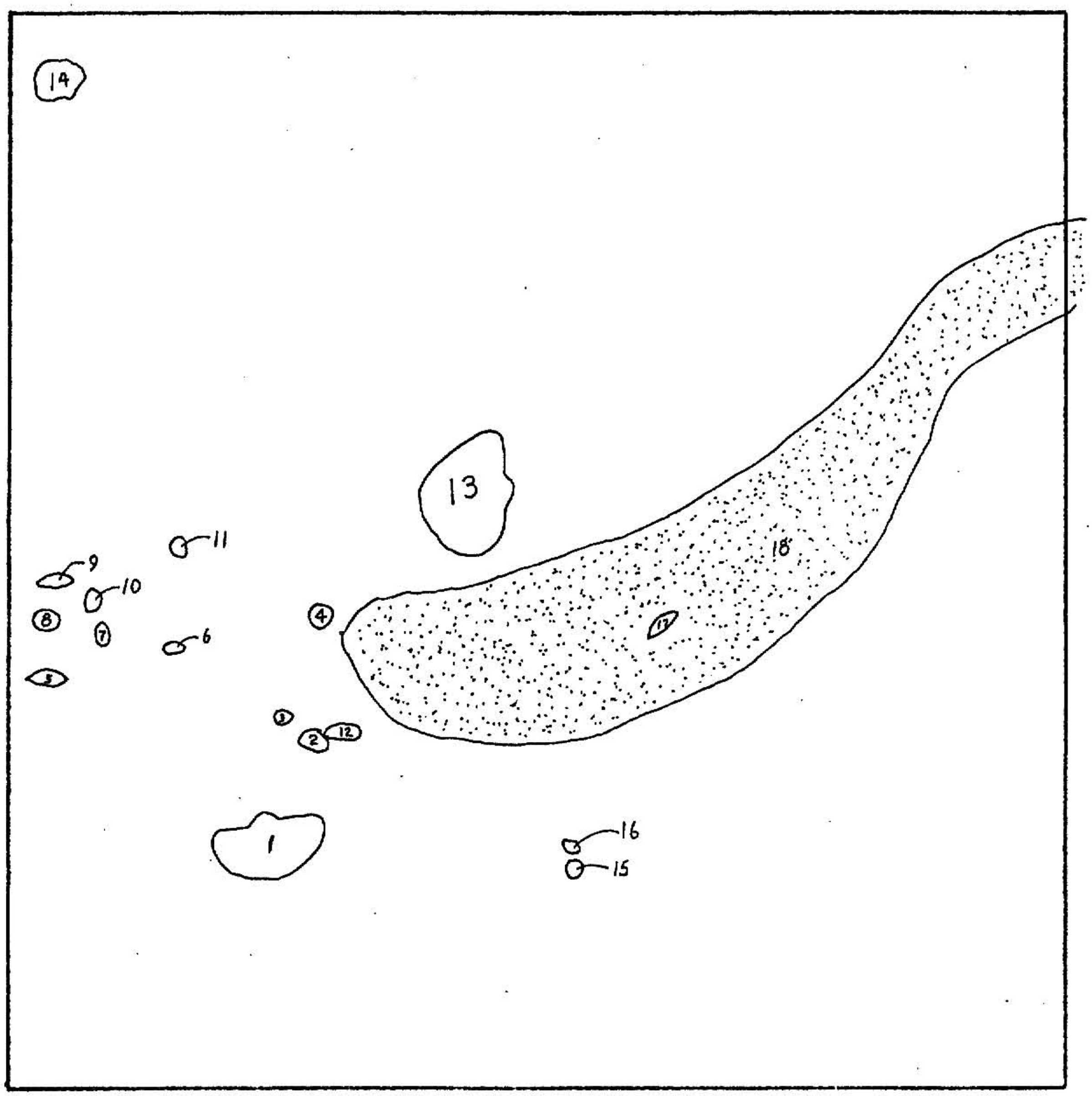


MICROFOSSIL RESIDUE SAMPLE NUMBER L - 8 - 5

Taxonomic Entities	Visual Percent Retained on Mesh Sieve			
	+10	+18	+32	+60
Foraminiferids				
Ammobaculites sp.				
Ammodiscus sp.				
Textularids				
Fusulinids				
Ectoprocts				
Ramose 1	2	1	1	
Ramose 2	2	tr		
Ramose 3				
Fenestrate 1		1	1	
Fenestrate 2	2	1	10	2
Brachiopods				
Inarticulate				
Lingula sp.				
Orbiculoidea sp.				
Petrocrania sp.	2			
Articulate				
Wellerella sp.				
Crurithyris sp.	22	20	5	
Derbyia sp.				
Meekella sp.				
Neochonetes sp.	15		1	
Lissochonetes sp.				
Reticulatia sp.				
Rhipidomella sp.				
Hustedia sp.				
Productid fragments	20	10	15	15
Brachiopod fragments		15	18	20
Molluscs				
Bivalve fragments	15		2	
Myalinid fragments				
Gastropods				
Loxonematids				
Arthropods				
Smooth ostracodes			1	3
Ornamented ostracodes				
Trilobite debris			tr	
Barnacle plates				
Echinoderms				
Crinoid debris		tr	5	2
Echinoid debris		1	1	3
Ophiuroid? ossicles		1	tr	
Holothurian sieve plates				tr
Fish debris				tr
Conodonts				
Burrow fillings				
Worm tubes				
Matrix and unidentified fragments	20	50	40	55

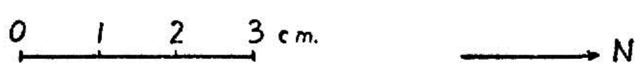
#	genus	long dem.	short dem.	orient	art	val	frag	epis	type pres	del
1	Comp	1.5	0.9	p/ccu		p			o	
2	crin	0.3	0.3	p/					o	
3	fus	0.4	0.2	i/					o	
4	Cru	0.3	0.2	p/cvu		p			o	
5	fus	0.5	0.2	p/					o	
6	Cru	0.3	0.2	p/cvu		b			o	
7	fus	0.4	0.2	p/					o	
8	fus	0.5	0.2	p/					o	
9	fus	0.7	0.2	p/					o	
10	fus	0.4	0.2	p/					o	
11	fus	0.3	0.2	p/					o	
12	fus	0.5	0.2	p/					o	
13	Hyst	1.7	1.1	p/ccu	c	p			o	
14	brac	0.6	0.6	p/		?	x		o	
15	fus	0.3	0.2	p/			x		o	
16	fus	0.4	0.2	i/					o	
17	fus	0.6	0.2	i/					o	
18	bur	10.0	2.0	p/				ffrag	cal	

L-8-6



D = 1.379

E = 0.645

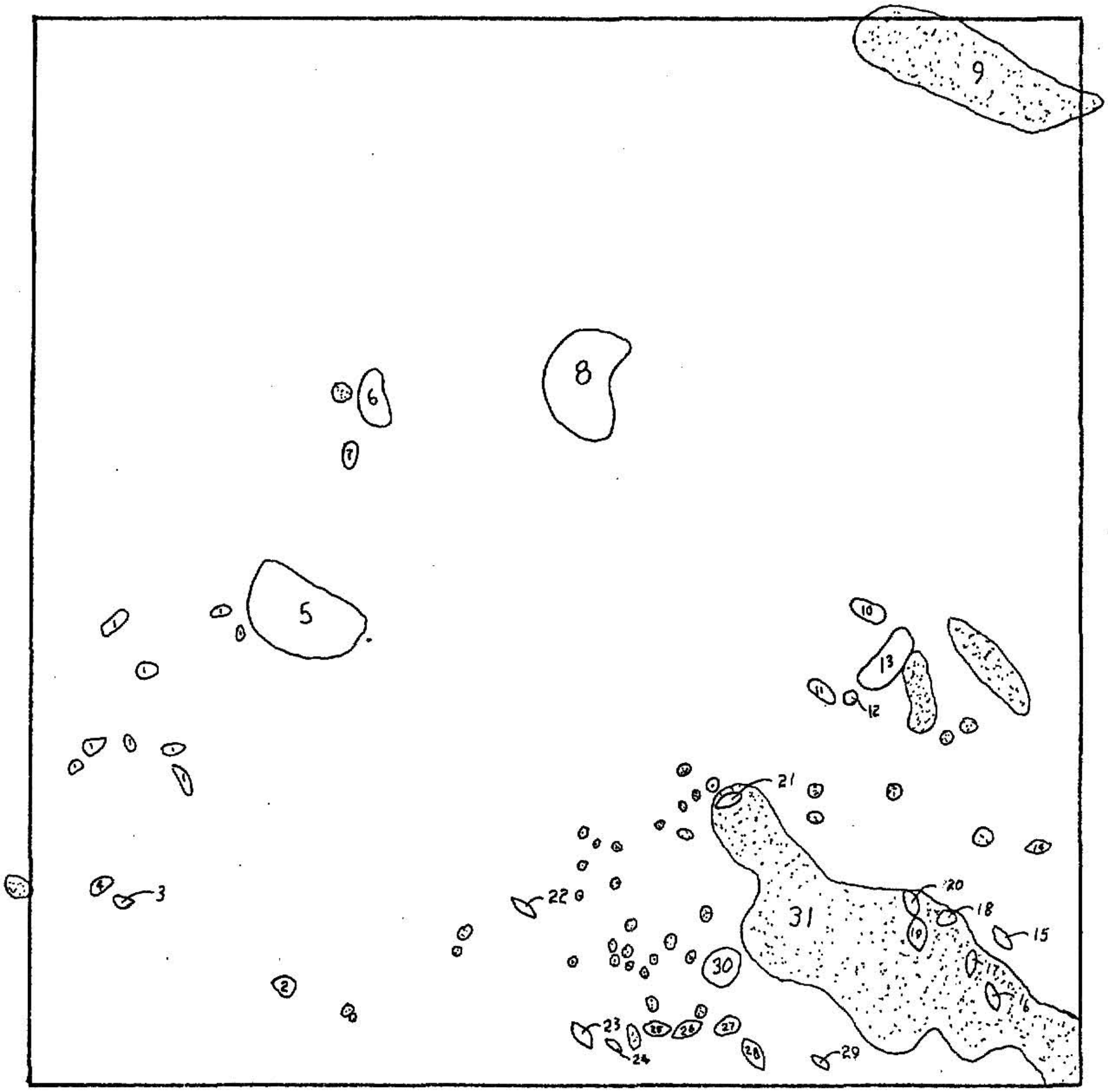


MICROFOSSIL RESIDUE SAMPLE NUMBER L - 8 - 6

Taxonomic Entities	Visual Percent Retained on Mesh Sieve			
	+10	+18	+32	+60
Foraminiferids				
Ammobaculites sp.				
Ammodiscus sp.				
Textularids				
Fusulinids			1	
Ectoprocts				
Ramose 1				
Ramose 2				
Ramose 3				
Fenestrate 1				
Fenestrate 2				tr
Brachiopods				
Inarticulate				
Lingula sp.				
Orbiculoidea sp.				
Petrocrania sp.	1			
Articulate				
Wellerella sp.				
Crurithyris sp.	3	1		
Derbyia sp.				
Meekella sp.				
Neochonetes sp.				
Lissochonetes sp.				
Reticulatia sp.				
Rhipidomella sp.	1			
Hustedia sp.				
Productid fragments	1	3	10	15
Brachiopod fragments			5	10
Molluscs				
Bivalve fragments				
Myalinid fragments				
Gastropods				
Loxonematids				
Arthropods				
Smooth ostracodes			7	4
Ornamented ostracodes				1
Trilobite debris				
Barnacle plates				
Echinoderms				
Crinoid debris	1	2		
Echinoid debris				tr
Ophiuroid? ossicles				
Holothurian sieve plates				
Fish debris	1			
Conodonts				
Burrow fillings		1		
Worm tubes				
Matrix and unidentified fragments	92	93	74	80

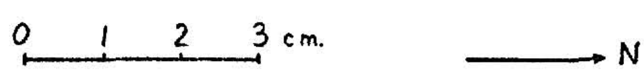
#	genus	long dem.	short dem.	orient	art	val	frag	epis	type pres	del
1	Orb	0.5	0.2	p/		?	x		o	
2	crin	0.2	0.1	p/					o	
3	fus	0.3	0.1	i/					o	
4	fus	0.3	0.1	p/					o	
5	Nech	1.8	1.0	p/cvu		b			o	
6	Nech	0.7	0.4	p/cvu		b			m	
7	fus	0.7	0.2	p/					o	
8	brac	1.7	1.2	p/		?	x		m	
9	bur	3.6	1.0	p/					cal	
10	fus	0.5	0.2	p/					o	
11	fus	0.5	0.2	p/					o	
12	crin	0.2	0.2	p/					o	
13	fi de	1.7	1.0	i/					o	
14	fus	0.5	0.1	p/					o	
15	fus	0.3	0.1	p/					o	
16	fus	0.6	0.2	p/					o	
17	fus	0.4	0.1	p/					o	
18	fus	0.4	0.1	p/					o	
19	fus	0.6	0.2	p/					o	
20	fus	0.6	0.2	p/					o	
21	fus	0.5	0.1	p/					o	
22	fus	0.2	0.1	p/					o	
23	fus	0.6	0.2	p/					o	
24	fus	0.4	0.1	p/					o	
25	fus	0.6	0.2	i/					o	
26	fus	0.6	0.1	i/					o	
27	fus	0.4	0.2	p/					o	
28	fus	0.5	0.2	p/					o	
29	fus	0.5	0.2	p/					o	
30	Cru	0.6	0.4	p/cvu		b			o	
31	bur	4.2	2.5	p/				ffrag	cal	

L-8-7



D = 1.266

E = 0.488

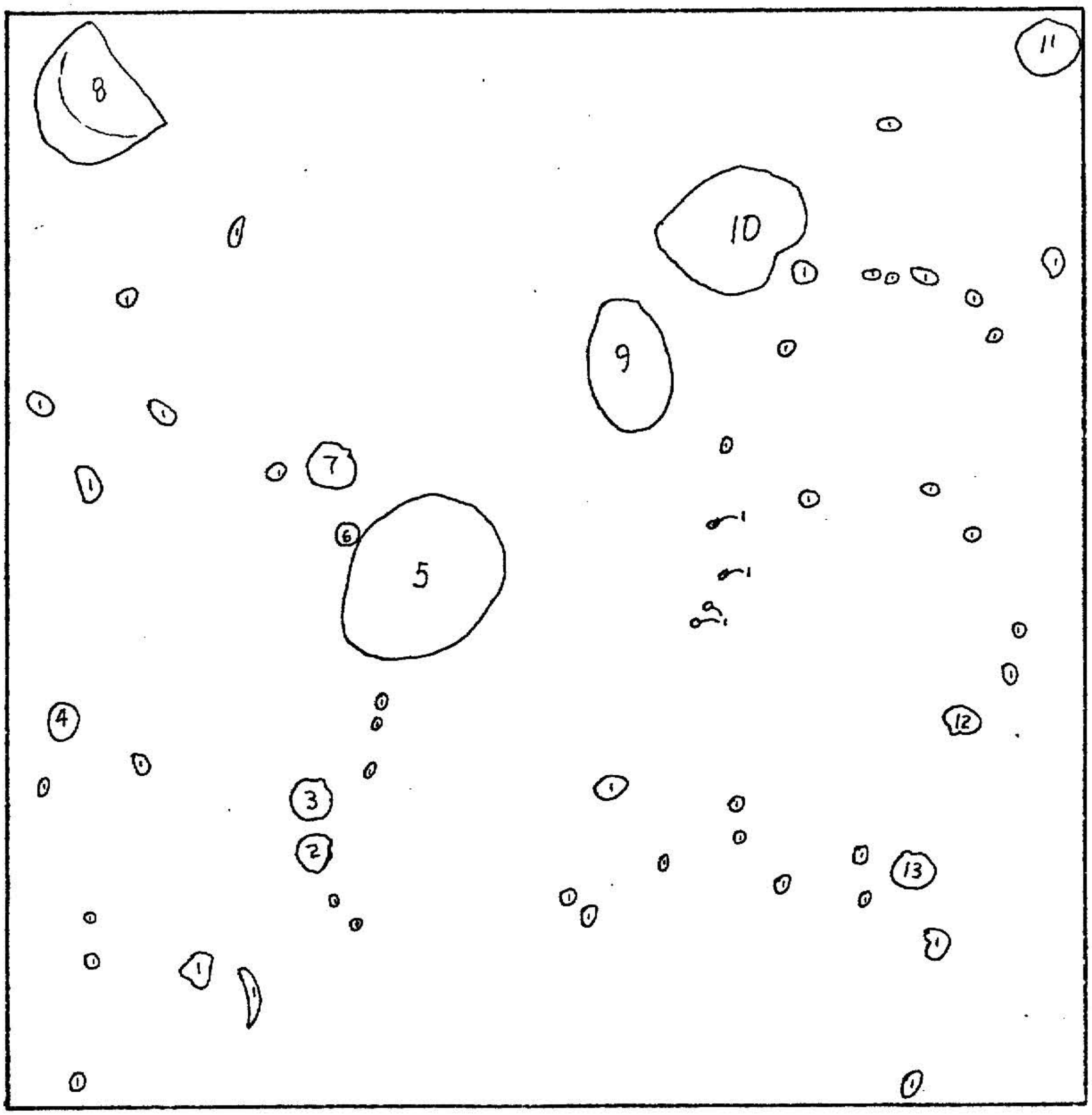


MICROFOSSIL RESIDUE SAMPLE NUMBER L - 8 - 7

Taxonomic Entities	Visual Percent Retained on Mesh Sieve			
	+10	+18	+32	+60
Foraminiferids				
Ammobaculites sp.				
Ammodiscus sp.				
Textularids			tr	
Fusulinids	91	89	10	3
Ectoprocts				
Ramose 1				
Ramose 2				
Ramose 3				
Fenestrate 1			3	
Fenestrate 2				
Brachiopods				
Inarticulate				
Lingula sp.				
Orbiculoidea sp.				
Petrocrania sp.				
Articulate				
Wellerella sp.				
Crurithyris sp.				
Derbyia sp.				
Meekella sp.				
Neochonetes sp.				
Lissochonetes sp.				
Reticulatia sp.				
Rhipidomella sp.				
Hustedia sp.				
Productid fragments			5	3
Brachiopod fragments				
Molluscs				
Bivalve fragments				
Myalinid fragments				
Gastropods				
Loxonematids				
Arthropods				
Smooth ostracodes		tr	tr	1
Ornamented ostracodes				tr
Trilobite debris		1	tr	
Barnacle plates				
Echinoderms				
Crinoid debris	2	tr	tr	tr
Echinoid debris		tr		tr
Ophiuroid? ossicles				
Holothurian sieve plates				
Fish debris				tr
Conodonts				
Burrow fillings	2			
Worm tubes				
Matrix and unidentified fragments	5	10	82	93

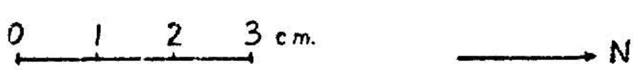
#	genus	long dem.	short dem.	orient	art	val	frag	epis	type pres	del
1	Orb	0.8	0.3	p/		?	x		o	
2	Cru	0.6	0.5	p/cvu		b			o	
3	Cru	0.6	0.5	p/cvu		p			o	
4	Lich	0.6	0.4	p/cvu	c	p			o	
5	prod	2.5	2.4	p/ccu		p			m	
6	Cru	0.4	0.3	p/cvu		b			o	
7	Cru	0.6	0.5	p/cvu		p			o	
8	Wilk	1.9	1.6	p/ccu		l	x		m	
9	Wilk	2.3	1.2	p/cvu		l			m	
10	Sch	2.8	2.5	p/ccu		r			m	
11	Rhip	1.4	1.1	i/cvu	c	p			o	
12	Cru	0.3	0.3	i/cvu		p			o	
13	Cru	0.7	0.7	i/cvu		p			o	

L-8-8



D = 2.322

E = 1.126

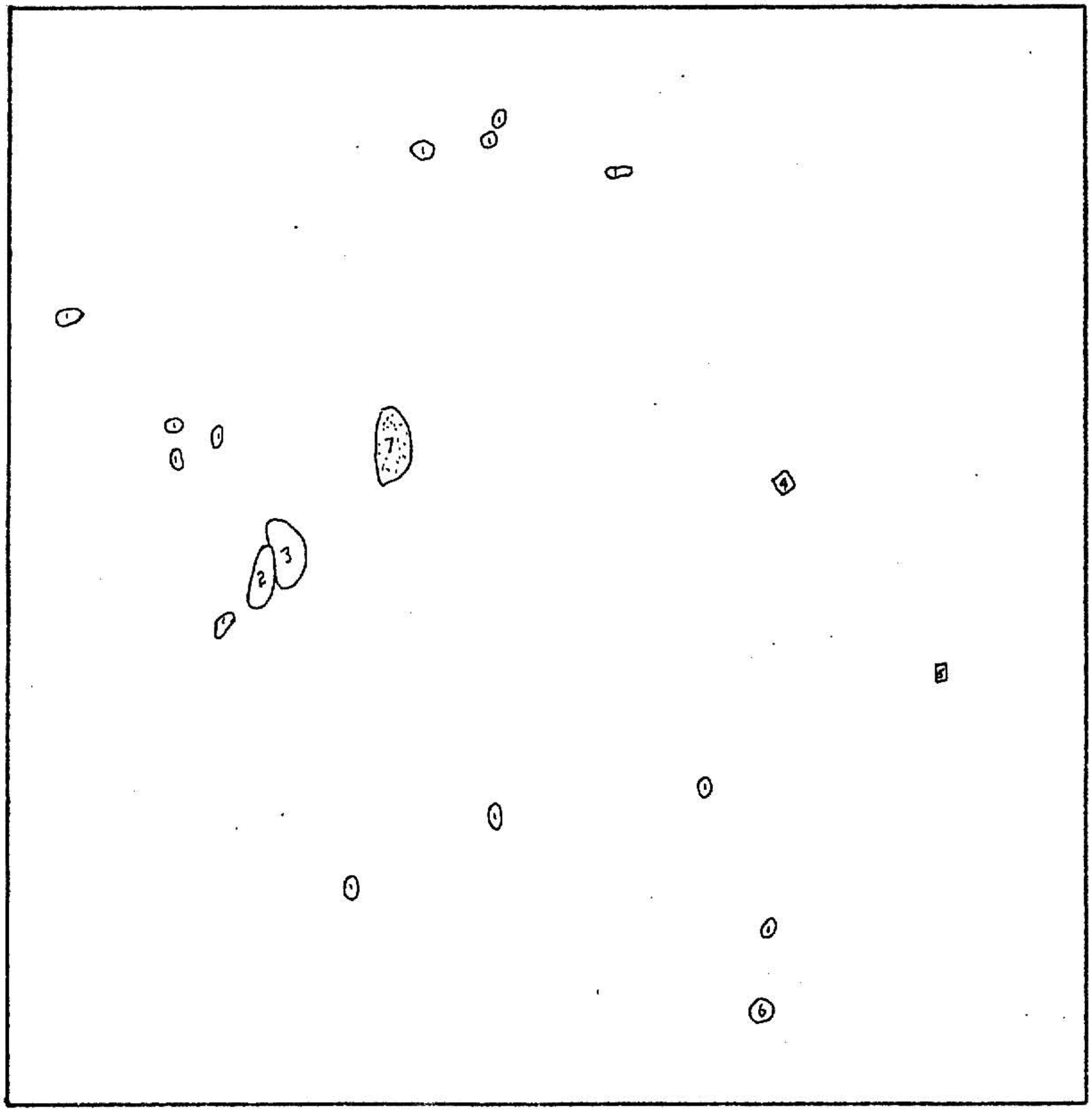


MICROFOSSIL RESIDUE   SAMPLE NUMBER L - 8 - 8

Taxonomic Entities	Visual Percent Retained on Mesh Sieve			
	+10	+18	+32	+60
Foraminiferids				
Ammobaculites sp.				
Ammodiscus sp.				
Textularids				
Fusulinids	4	15	7	tr
Ectroprocts				
Ramose 1				
Ramose 2				
Ramose 3				
Fenestrate 1				
Fenestrate 2				
Brachiopods				
Inarticulate				
Lingula sp.			tr	
Orbiculoidea sp.	2	1	3	10
Petrocrania sp.				
Articulate				
Wellerella sp.				
Crurithyris sp.	3	1	1	
Derbyia sp.				
Meekella sp.		1		
Neochonetes sp.				
Lissochonetes sp.				
Reticulatia sp.				
Rhipidomella sp.	1			
Hustedia sp.				
Productid fragments		1	tr	tr
Brachiopod fragments			1	2
Molluscs				
Bivalve fragments				
Myalinid fragments				
Gastropods				
Loxonematids			tr	
Arthropods				
Smooth ostracodes			1	1
Ornamented ostracodes				
Trilobite debris				
Barnacle plates				
Echinoderms				
Crinoid debris		2	tr	tr
Echinoid debris			tr	
Ophiuroid? ossicles				
Holothurian sieve plates				
Fish debris		tr	tr	tr
Conodonts				
Burrow fillings				
Worm tubes				
Matrix and unidentified fragments	90	79	86	87

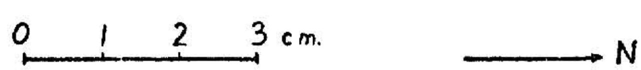
#	genus	long dem.	short dem.	orient	art	val	frag	epis	type pres	del
1	Orb	0.4-	0.2-	i/&p/			x		o	
2	tril	0.8	0.5	p/cvu			x		o	
3	brac	1.2	0.5	i/		?	x		o	
4	crin	0.2	0.2	p/					o	
5	crin	0.1	0.1	p/					o	
6	Hust	0.3	0.2	p/cvu		?	x		o	
7	bur	0.8	0.2	p/					lim	

L-8-9



D = 1.512

E = 0.719

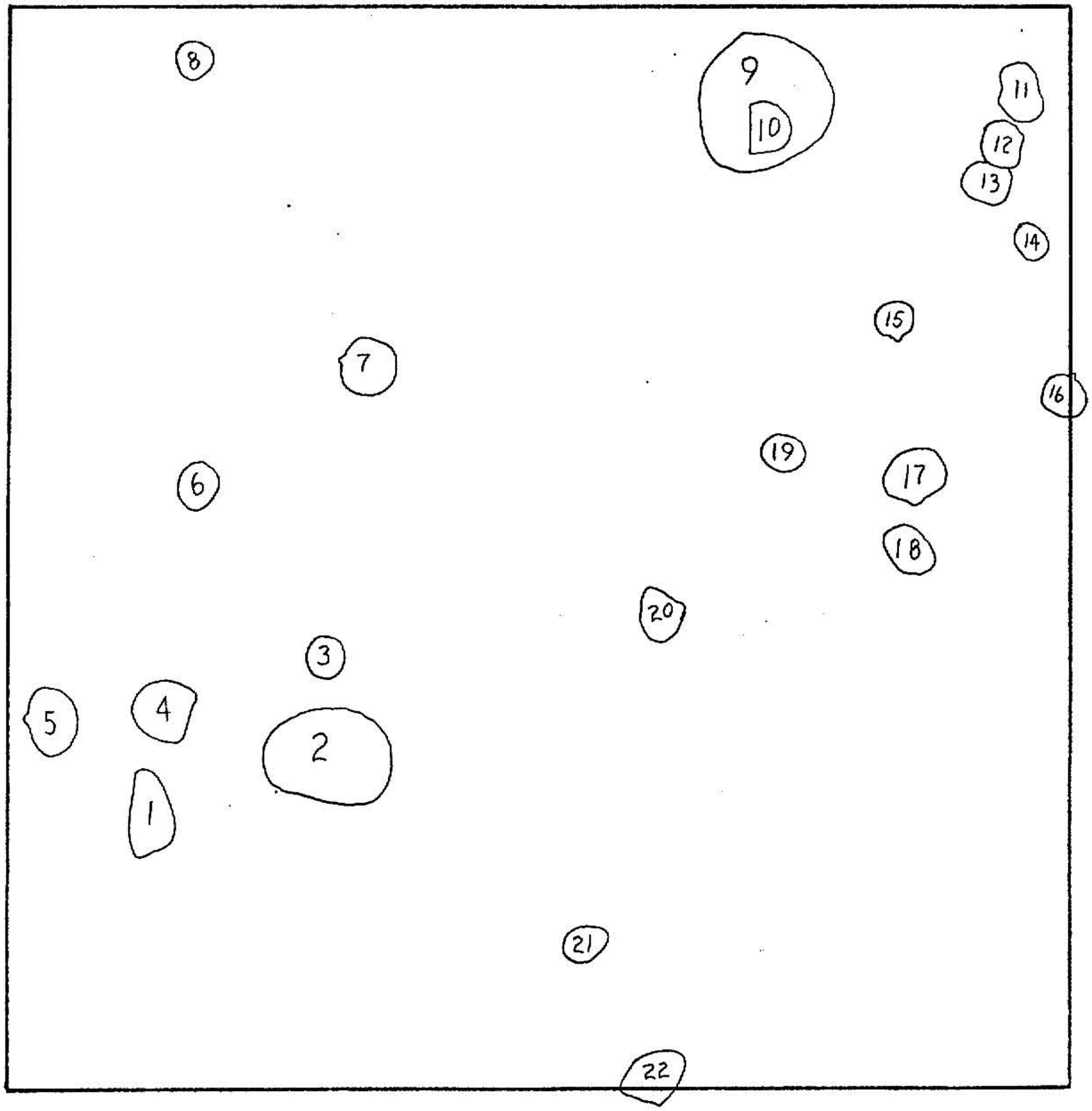


MICROFOSSIL RESIDUE SAMPLE NUMBER L - 8 - 9

Taxonomic Entities	Visual Percent Retained on Mesh Sieve			
	+10	+18	+32	+60
Foraminiferids				
Ammobaculites sp.				
Ammodiscus sp.				
Textularids				
Fusulinids	1	3	2	1
Ectoprocts				
Ramose 1				
Ramose 2			tr	
Ramose 3				
Fenestrate 1				
Fenestrate 2				
Brachiopods				
Inarticulate				
Lingula sp.		1	1	
Orbiculoidea sp.	10	5	5	15
Petrocrania sp.				
Articulate				
Wellerella sp.				
Crurithyris sp.	20	10	1	
Derbyia sp.				
Meekella sp.				
Neochonetes sp.				
Lissochonetes sp.				
Reticulatia sp.				
Rhipidomella sp.				
Hustedia sp.				
Productid fragments		tr	tr	3
Brachiopod fragments				
Molluscs				
Bivalve fragments				
Myalinid fragments				
Gastropods				
Loxonematids				
Arthropods				
Smooth ostracodes				
Ornamented ostracodes				
Trilobite debris				
Barnacle plates				
Echinoderms				
Crinoid debris	2	1	tr	
Echinoid debris				
Ophiuroid? ossicles				
Holothurian sieve plates				
Fish debris		tr	tr	tr
Conodonts				tr
Burrow fillings				
Worm tubes				
Matrix and unidentified fragments	67	80	90	80

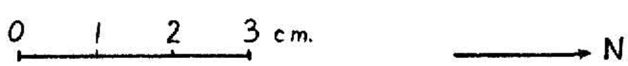
#	genus	long dem.	short dem.	orient	art	val	frag	epis	type pres	del
1	Ling	1.2	0.7	p/cvu		?			o&m	
2	uBv	1.8	1.6	p/cvu					o&m	
3	Cru	1.1	0.9	p/cvu		p			o	
4	Pet	0.8	0.8	p/cvu		p			o	
5	Cru	0.9	0.8	p/cvu		p			o	
6	Cru	0.8	0.8	p/cvu		p			o	
7	Cru	1.1	0.9	p/cvu		p			o	
8	Ling	0.9	0.5	p/cvu		?			o&m	
9	brac	1.9	1.9	p/cvu		?			m	
10	Cru	0.7	0.6	p/cvu		b			o	
11	Cru	0.6	0.6	i/cvu		p			o	
12	Ling	0.9	0.6	p/cvu		?			m	
13	Cru	0.8	0.7	p/cvu		p			o	
14	Cru	0.5	0.5	p/ccu		p			m	
15	Cru	1.0	0.8	p/cvu		p			o	
16	Cru	0.9	0.8	p/cvu		p			o	
17	Cru	0.9	0.6	p/cvu		b			o	
18	Cru	0.5	0.5	p/ccu		p			m	
19	Cru	0.9	0.8	p/ccu	c	p			o	
20	Cru	0.9	0.7	p/cvu		p			o	
21	Orb	0.7	0.6	p/cvu		?	x		o	
22	Ling	1/4	1.0	p/cvu		?	x		o	

L-10-1



D = 1.186

E = 0.692

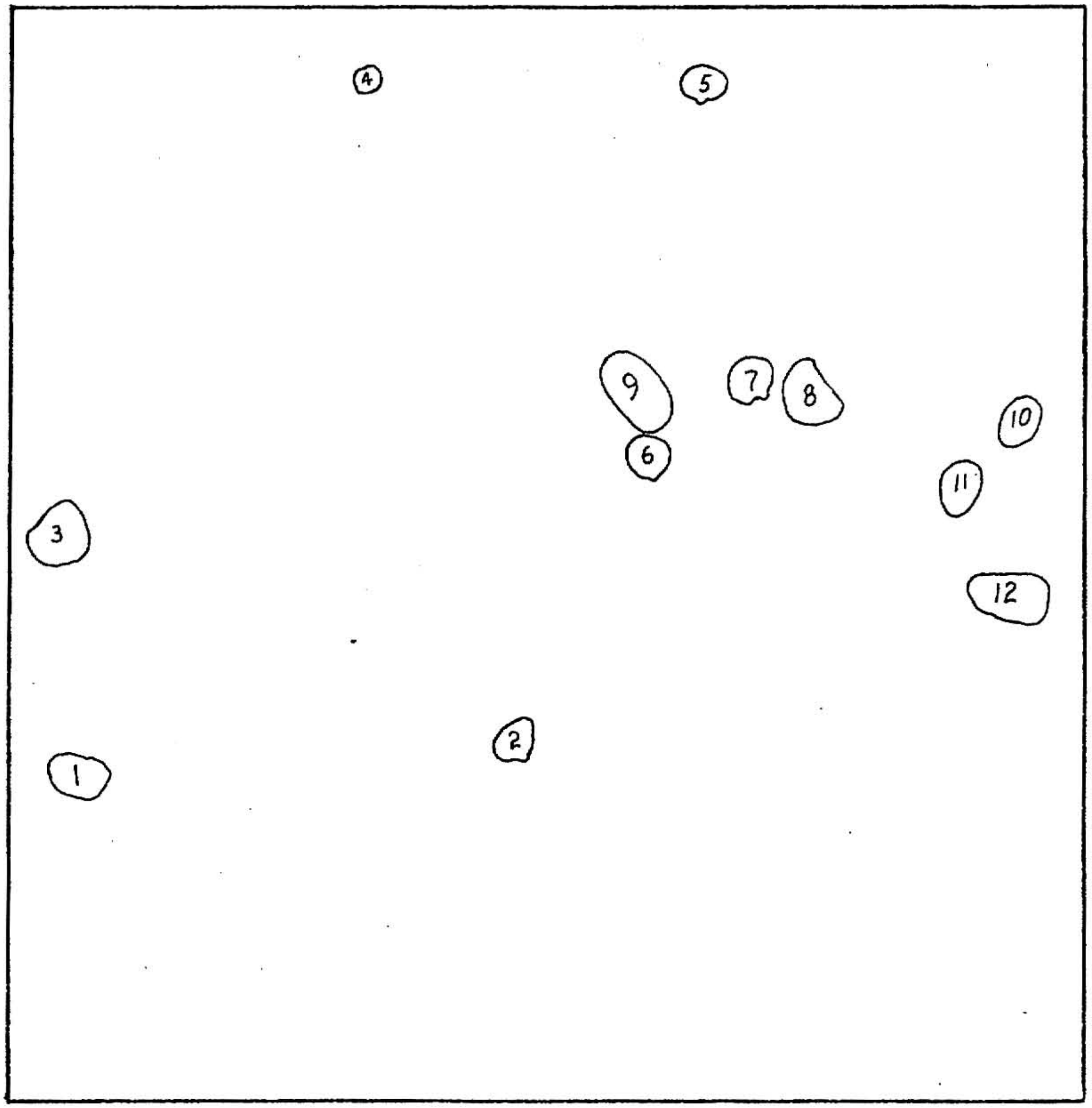


MICROFOSSIL RESIDUE SAMPLE NUMBER L - 10 - 1

Taxonomic Entities	Visual Percent Retained on Mesh Sieve			
	+10	+18	+32	+60
Foraminiferids				
Ammobaculites sp.				10
Ammodiscus sp.				2
Textularids				
Fusulinids				
Ectoprocts				
Ramose 1				
Ramose 2				
Ramose 3				
Fenestrate 1				
Fenestrate 2				
Brachiopods				
Inarticulate				
Lingula sp.		tr	1	2
Orbiculoidea sp.				
Petrocrania sp.			tr	
Articulate				
Wellerella sp.				
Crurithyris sp.	98	70	50	10
Derbyia sp.		1		
Meekella sp.				
Neochonetes sp.		2	1	
Lissochonetes sp.				
Reticulatia sp.				
Rhipidomella sp.				
Hustedia sp.				
Productid fragments			tr	3
Brachiopod fragments		25	47	71
Molluscs				
Bivalve fragments				
Myalinid fragments				
Gastropods				
Loxonematids				
Arthropods				
Smooth ostracodes				
Ornamented ostracodes				
Trilobite debris				
Barnacle plates				
Echinoderms				
Crinoid debris	2	1	1	1
Echinoid debris				
Ophiuroid? ossicles				
Holothurian sieve plates				
Fish debris				tr
Conodonts				
Burrow fillings				
Worm tubes				

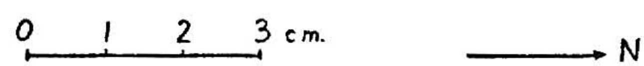
#	genus	long dem.	short dem.	orient	art	val	frag	epis	type pres	del
1	Cru	0.9	0.8	p/cvu		p	x		o	
2	Cru	0.7	0.5	p/ccu		p	x		o	
3	Cru	0.9	0.7	p/cvu		b			o	
4	Orb	0.3	0.2	p/		?	x		o	
5	Cru	0.6	0.5	p/cvu	c	p			o	
6	Cru	0.5	0.5	p/cvu		p			o	
7	Cru	0.6	0.5	p/cvu		p			o	
8	Cru	0.9	0.6	p/cvu		b			o	
9	Ling	1.5	0.8	p/		?			o&m	
10	Orb	0.8	0.5	p/cvu		p			o&m	
11	Cru	0.8	0.7	p/cvu		p			o	
12	Ling	0.9	0.5	p/ccu		?	x		o&m	

L-10-2



D = 1.222

E = 0.947

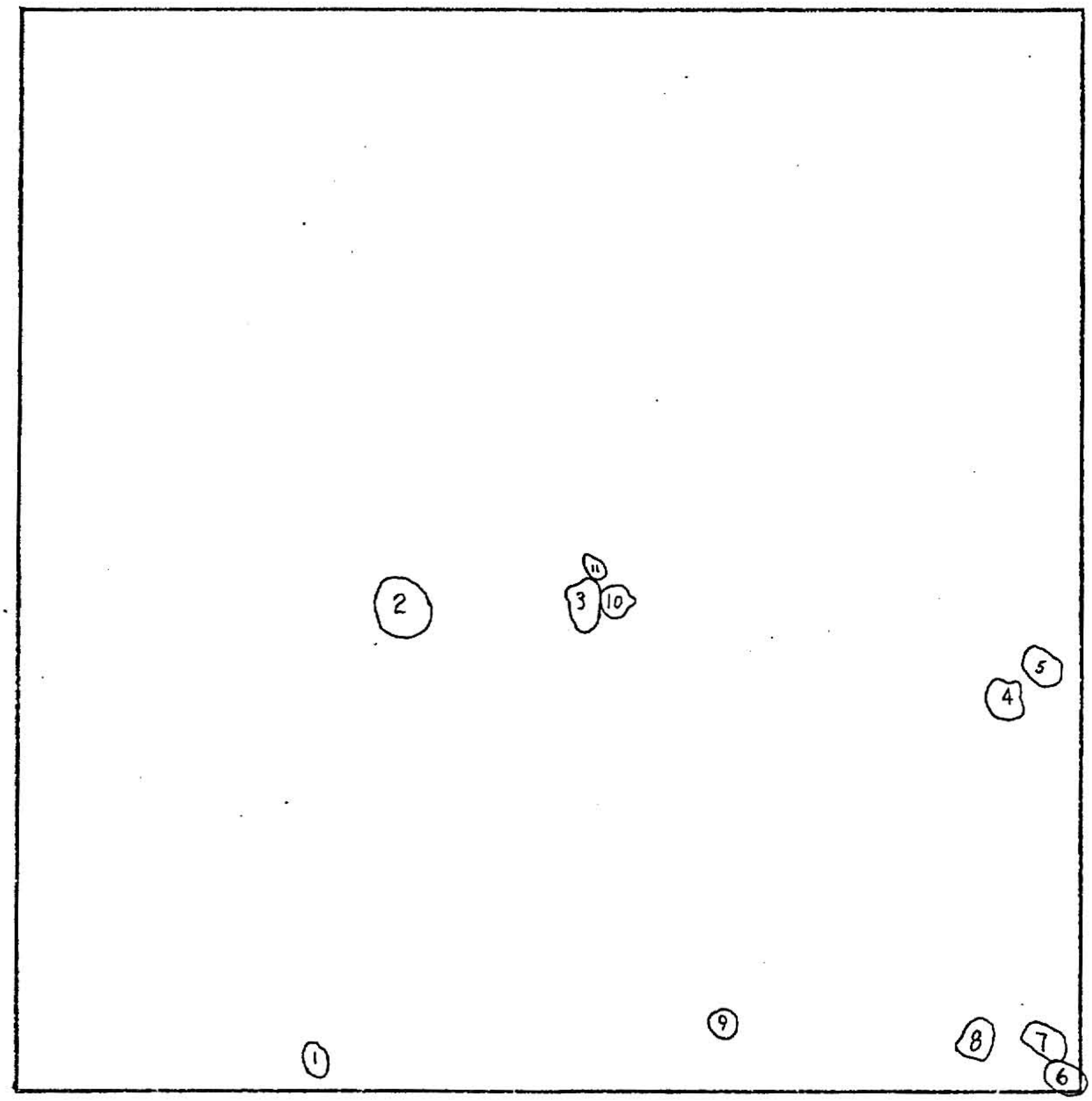


MICROFOSSIL RESIDUE   SAMPLE NUMBER L - 10 - 2

Taxonomic Entities	Visual Percent Retained on Mesh Sieve			
	+10	+18	+32	+60
Foraminiferids				
Ammobaculites sp.				15
Ammodiscus sp.				5
Textularids				
Fusulinids				
Ectoprocts				
Ramose 1				
Ramose 2				
Ramose 3				
Fenestrate 1				
Fenestrate 2				
Brachiopods				
Inarticulate				
Lingula sp.		1	10	20
Orbiculoidea sp.				
Petrocrania sp.				
Articulate				
Wellerella sp.				
Crurithyris sp.	99	60	50	20
Derbyia sp.				
Meekella sp.				
Neochonetes sp.	1	1	tr	
Lissochonetes sp.				
Reticulatia sp.				
Rhipidomella sp.				
Hustedia sp.				
Productid fragments		1	tr	
Brachiopod fragments		20	39	39
Molluscs				
Bivalve fragments				
Myalinid fragments				
Gastropods				
Loxonematids				
Arthropods				
Smooth ostracodes				
Ornamented ostracodes				
Trilobite debris				
Barnacle plates		1	tr	
Echinoderms				
Crinoid debris		1	tr	
Echinoid debris				tr
Ophiuroid? ossicles			tr	
Holothurian sieve plates				tr
Fish debris				1
Conodonts				
Burrow fillings				
Worm tubes				
Matrix and unidentified fragments		15		

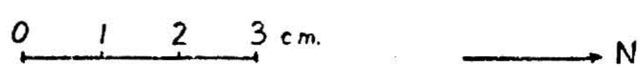
#	genus	long dem.	short dem.	orient	art	val	frag	epis	type pres	del
1	Cru	0.4	0.3	p/cvu		p	x		o	
2	Cru	0.8	0.7	p/ccu		p			m	
3	Cru	0.8	0.7	p/ccu		p			o	
4	Cru	0.6	0.5	p/cvu		p			o	
5	Cru	0.5	0.4	p/cvu		p			o	
6	Cru	0.8	0.6	p/cvu		p			o	
7	Cru	0.7	0.6	p/cvu		b			o	
8	Cru	0.6	0.5	p/cvu		p			o	
9	Cru	0.7	0.6	p/cvu		p			o	
10	Cru	0.5	0.4	p/cvu		p			o	
11	Orb	0.3	0.1	p/		?	x		o	

L-10-3



D = 0.468

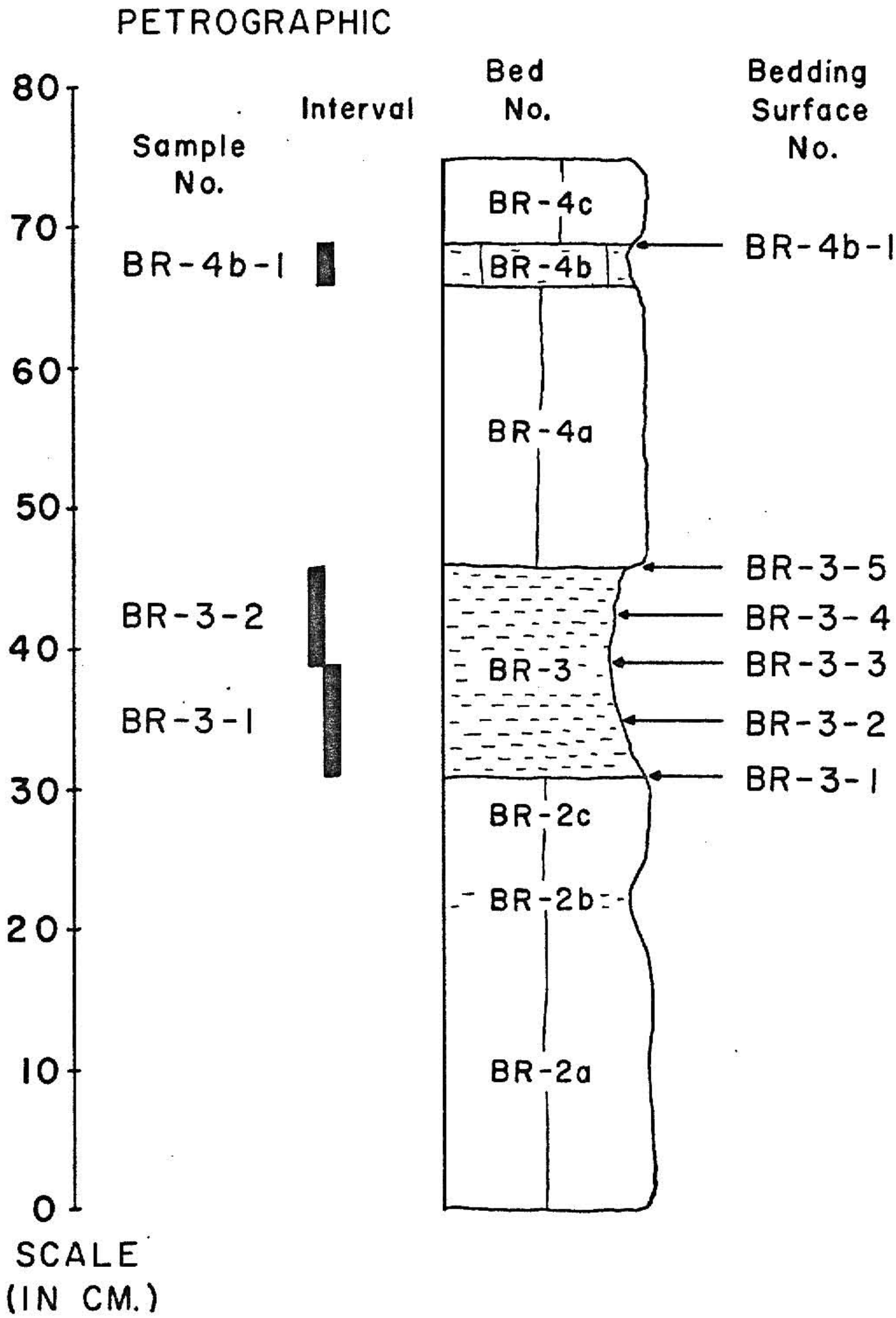
E = 0.788



MICROFOSSIL RESIDUE SAMPLE NUMBER L - 10 - 3

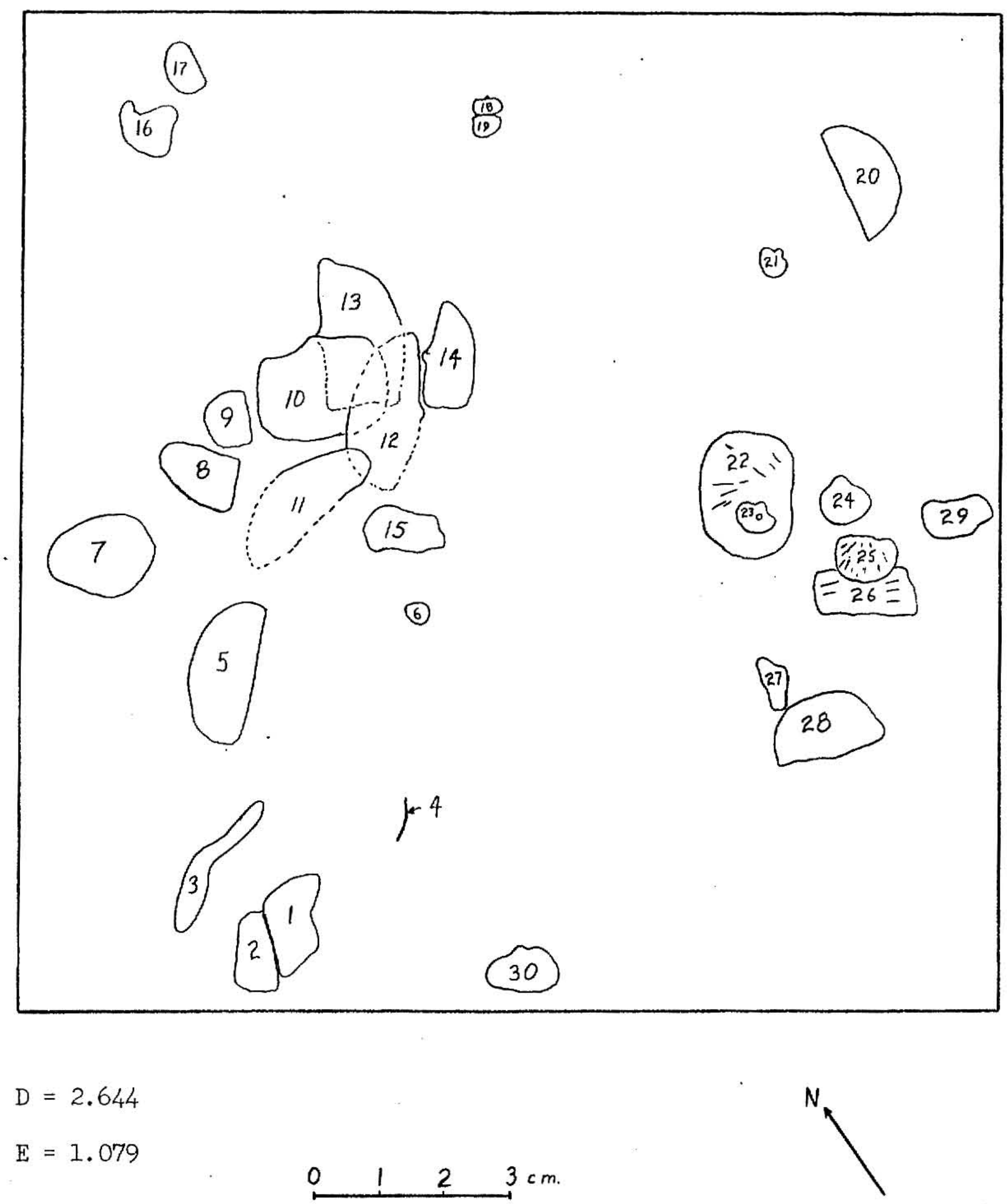
Taxonomic Entities	Visual Percent Retained on Mesh Sieve			
	+10	+18	+32	+60
Foraminiferids				
Ammobaculites sp.				tr
Ammodiscus sp.				
Textularids				
Fusulinids				
Ectoprocts				
Ramose 1				
Ramose 2				
Ramose 3				
Fenestrate 1				
Fenestrate 2				
Brachiopods				
Inarticulate				
Lingula sp.		tr	1	5
Orbiculoidea sp.				
Petrocrania sp.		1	tr	
Articulate				
Wellerella sp.				
Crurithyris sp.	100	84	60	14
Derbyia sp.				
Meekella sp.				
Neochonetes sp.		1		
Lissochonetes sp.				
Reticulatia sp.				
Rhipidomella sp.				
Hustedia sp.				
Productid fragments			1	tr
Brachiopod fragments		5	20	60
Molluscs				
Bivalve fragments				
Myalinid fragments				
Gastropods				
Loxonematids				
Arthropods				
Smooth ostracodes				tr
Ornamented ostracodes				
Trilobite debris				
Barnacle plates				
Echinoderms				
Crinoid debris			2	
Echinoid debris				tr
Ophiuroid? ossicles			2	
Holothurian sieve plates				
Fish debris				tr
Conodonts				
Burrow fillings				
Worm tubes				
Matrix and unidentified fragments		10	16	20

BLUE RIVER (BR) SECTION



#	genus	long dem.	short dem.	orient	art	val	frag	epis	type pres	del
1	Cru	0.4	0.4	p/cvu		p			o	
2	prod	0.6	0.5	p/cvu			x		o	
3	brac	0.9	0.5	p/ccu		?	x		o	
4	crin	0.3	0.2	i/					o	
5	Ret	2.9	2.7	p/cvu		p			o	
6	Derb	4.2	2.2	i/cvu	c				o	
7	Nesp	2.4	1.3	i/cvu			x		o	
8	Nech	2.6	1.3	p/cvu		b			o	
9	brac	0.9	0.6	i/			x		o	
10	Cru	0.5	0.4	p/cvu		p			o	
11	crin	0.6	0.2	p/					o	
12	Hyst?	1.2	1.2	p/cvu		p			o	
13	Cru	0.9	0.9	p/cvu		p			o	
14	Comp	1.1	0.7	i/cvu		?	x		o	
15	Cru	0.6	0.5	p/cvu	c	p			o	
16	Ret	2.7	2.6	p/cvu		p			o	
17	Nesp	4.8	2.3	p/ccu		b			o	
18	Derb	0.8	0.4	i/cvu		?			o	
19	brac	0.4	0.4	p/ccu		?	x		m	
20	brac	0.6	0.3	i/			x		o	
21	Ret	1.8	1.1	p/ccu		b	x		o	
22	Nesp	4.8	2.6	p/cvu		b			o	
23	Pina	3.6	0.9	p/cvu		?	x		m	
24	Cru	0.5	0.4	p/cvu		p			o	
25	brac	0.6	0.6	p/ccu		?	x		o	
26	r III	1.9	0.2	i/					o	
27	Nesp	3.6	1.8	p/ccu		p			o	
28	Hust	0.9	0.6	p/cvu		?	x		o	

BR-3-1


17
16
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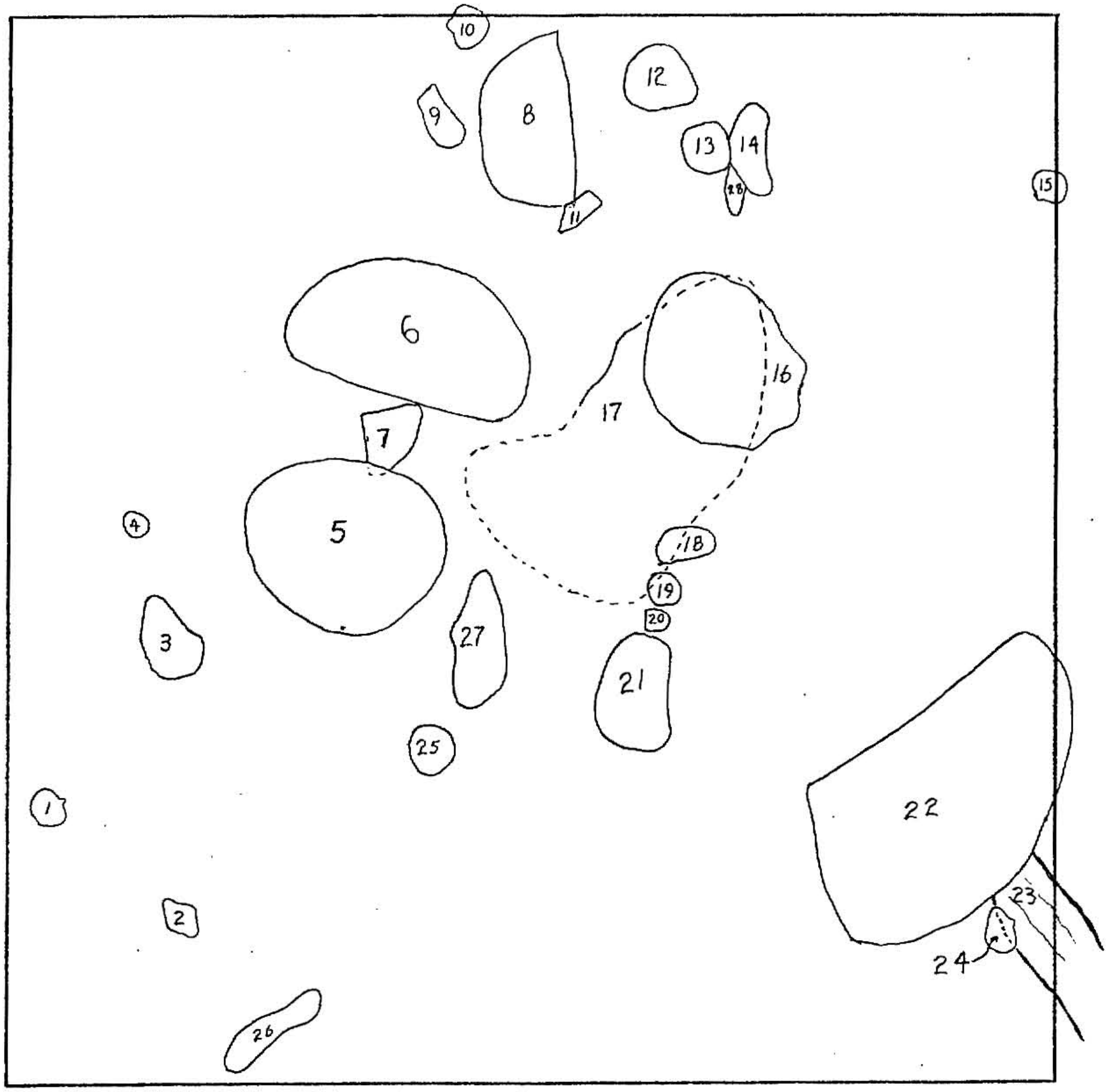
12
8
22
24
29
11
23
25
15
26
7
6
5
27
28
4
3
1
2
30
D = 2.644
E = 1.079
0 1 2 3 cm.
N

#	genus	long dem.	short dem.	orient	art	val	frag	epis	type pres	del
1	Lino	1.3	0.8	p/ccu			x		m	
2	Nech	2.6	1.2	i/cvu		b			o	
3	r III	1.9	0.2						o	
4	brac	0.5	0.2	i/			x		o	
5	Nech	2.5	1.2	i/cvu		b			o	
6	Cru	0.4	0.3	p/cvu		p			o	
7	uBv	1.7	1.2	p/ccu		?			m	
8	Apec	1.3	0.8	p/cvu		?	x		m	
9	brac	0.8	0.7	p/			x		o	
10	Ret	2.1	1.8	p/cvu		b			m	
11	Nech	2.5	1.3	i/ccu		p			o	
12	Nech	2.5	1.2	i/cvu		p			o	
13	Nech	2.8	1.4	i/cvu		p			o	
14	Nech	2.0	0.9	i/cvu		b			o	
15	uBv	1.3	0.7	p/ccu			x		o	
16	f II	0.9	0.7	p/					o	
17	Nech	1.1	0.6	i/ccu		p			o	
18	brac	0.3	0.3	i/			x		o	
19	brac	0.3	0.2	i/			x		o	
20	Nech	2.0	1.0	i/ccu		p			m	
21	Cru	0.4	0.3	p/cvu		p	x		o	
22	Derb	1.9	1.5	i/cvu	-c	b			o	
23	Cru	0.6	0.4	p/cvu		p	x		o	
24	Cru	0.8	0.7	p/cvu		p			o	
25	Derb	0.9	0.7	p/cvu		b			o	
26	f II	1.4	0.8	p/zeu					o	x
27	Nech	1.5	0.9	p/cvu		p			o	
28	brac	0.9	0.5	p/ccu			x		p	
29	r I	1.2	0.7	p/cvu					o	
30	Derb	0.8	0.4	i/			x		o	

BR-3-2



D = 3.086

E = 1.199

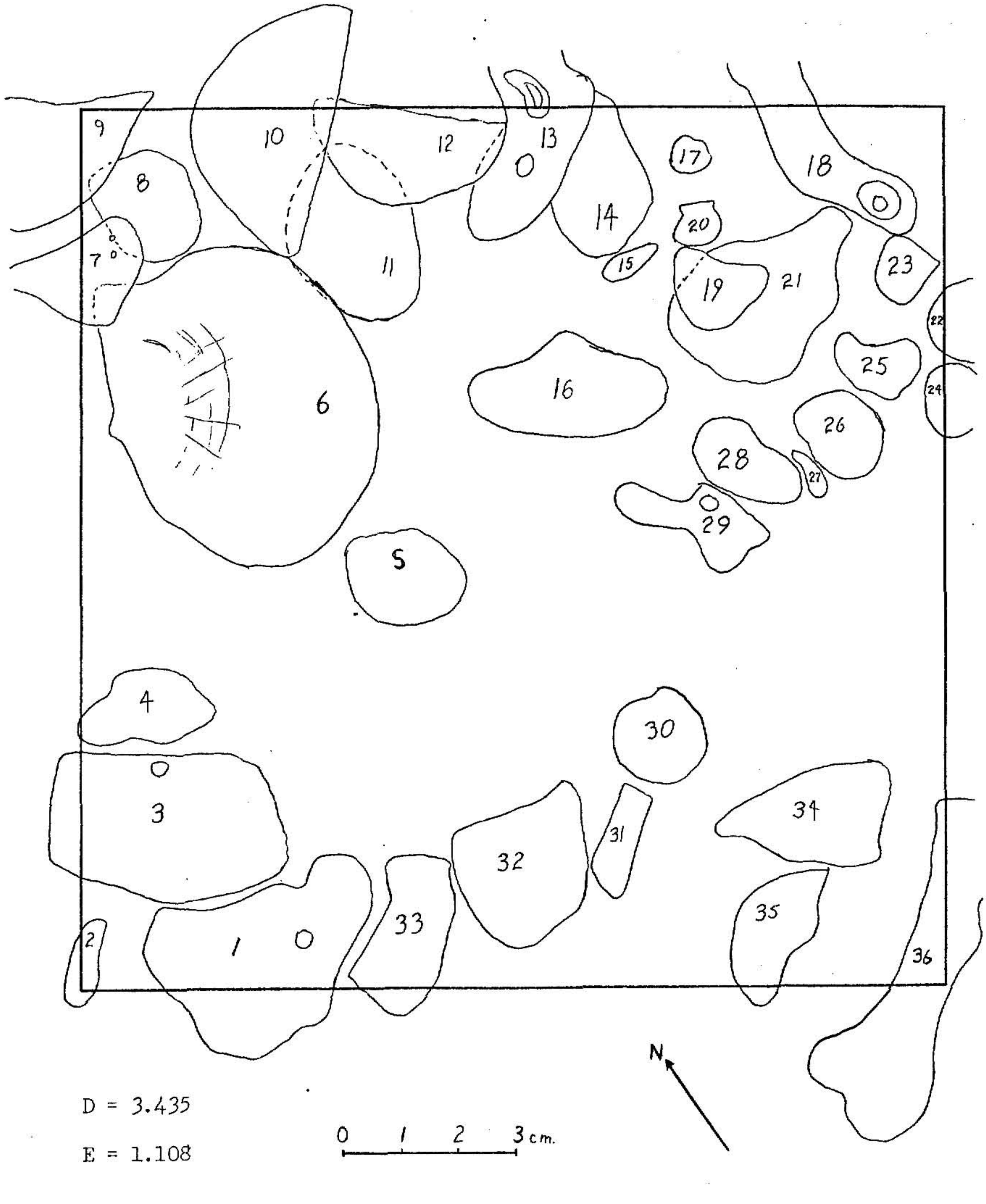
0 1 2 3 cm.

MICROFOSSIL RESIDUE SAMPLE NUMBER BR - 3 - 2

Taxonomic Entities	Visual Percent Retained on Mesh Sieve			
	+10	+18	+32	+60
Foraminiferids				
Ammobaculites sp.				1
Ammodiscus sp.				
Textularids				
Fusulinids				
Ectoprocts				
Ramose 1				
Ramose 2	4		1	
Ramose 3				
Fenestrate 1	15	7	3	
Fenestrate 2		5		
Brachiopods				
Inarticulate				
Lingula sp.				
Orbiculoidea sp.				
Petrocrania sp.	5			
Articulate				
Wellerella sp.				
Crurithyris sp.	2	5		
Derbyia sp.				
Meekella sp.				
Neochonetes sp.	1			
Lissochonetes sp.				
Reticulatia sp.				
Rhipidomella sp.				
Hustedia sp.				
Productid fragments	2			
Brachiopod fragments	68	80	85	89
Molluscs				
Bivalve fragments				
Myalinid fragments				
Gastropods				
Loxonematids				
Arthropods				
Smooth ostracodes			2	7
Ornamented ostracodes		1		
Trilobite debris		1		
Barnacle plates				
Echinoderms				
Crinoid debris			5	1
Echinoid debris	1	1	3	
Ophiuroid? ossicles	1			1
Holothurian sieve plates				
Fish debris			1	1
Conodonts				
Burrow fillings				
Worm tubes				

#	genus	long dem.	short dem.	orient	art	val	frag	epis	type pres	del
1	f II	4.0	3.1	p/zeu			x		o	x
2	Pina	1.8	0.7	p/ccu		l			m	
3	f II	3.8	2.6	p/					o	
4	Ret	2.3	1.4	p/ccu			x		o	
5	Ret	1.9	1.4	p/cvu		p			o	
6	Ret	5.9	4.4	p/cvu		p			o	
7	Pina	2.4	1.8	p/cvu		r			m	
8	Nesp	4.9	2.4	p/cvu		p			o	
9	Nesp	5.0	2.7	p/cvu		p			o	
10	Nesp	4.5	2.6	p/cvu		b			o	
11	Nesp	?	2.6	p/ccu		b			o&m	
12	Lino	4.2	3.7	p/cvu	c	p			o	
13	r III	2.3	1.3	p/					o	
14	r IV	0.8	0.4	i/					o	
15	r II	0.8	0.1	p/					o	
16	Nesp	4.8	2.2	p/ccu		p			o	
17	Cru	0.7	0.5	p/cvu	c	p			o	
18	r III	5.3	0.8	p/					o	
19	Apec	2.2	1.6	p/ccu		?	x		m	
20	Apec	0.9	0.8	p/cvu		?			m	
21	f II	3.4	2.8	p/			x		o	
22	Canc?	1.2	0.9	p/cvu		p			o&m	
23	uBv	1.3	1.3	p/cvu			x		m	
24	Canc?	1.3	1.1	i/cvu		p			o	
25	Derb	1.7	0.9	p/ccu		b	x		m	
26	Canc?	2.2	1.9	p/cvu		p			o	
27	Nesp	1.2	0.6	p/ccu			x		o	
28	Lino	0.7	0.6	/ccu			x		m	
29	f II	2.7	1.3	i/			x		o	
30	Canc?	1.9	1.7	p/cvu					o	
31	Myl	2.7	1.2	p/cvu		r	x		m	
32	f I	2.7	2.5	p/zeu			x		o	
33	Ret	3.3	1.5	p/ccu		p	x		o	
34	f II	3.2	1.8	p/zeu			x		m	
35	Nesp	5.2	1.4	p/cvu		p			o	
36	r III	7.2	1.2	p/					o	

BR-3-3



D = 3.435

E = 1.108

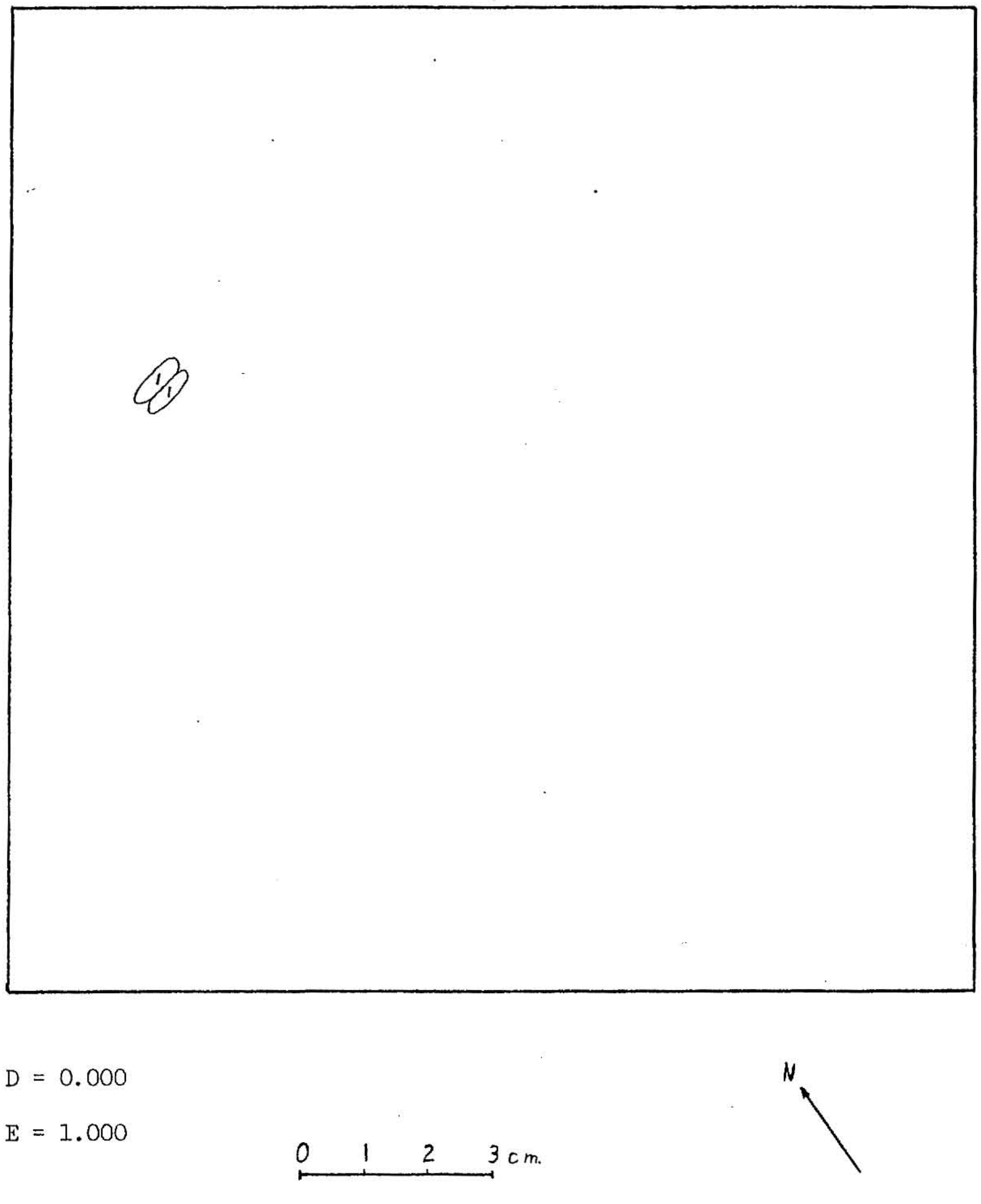
MICROFOSSIL RESIDUE — SAMPLE NUMBER BR - 3 - 3

Taxonomic Entities	Visual Percent Retained on Mesh Sieve			
	+10	+18	+32	+60
Foraminiferids				
Ammobaculites sp.				2
Ammodiscus sp.				1
Textularids				
Fusulinids				
Ectoprocts				
Ramose 1	4			
Ramose 2	2	3		
Ramose 3	30			
Fenestrate 1			5	4
Fenestrate 2	2	10	8	3
Brachiopods				
Inarticulate				
Lingula sp.				
Orbiculoidea sp.				
Petrocrania sp.	4			
Articulate				
Wellerella sp.				
Crurithyris sp.	10	15	10	
Derbyia sp.				
Meekella sp.				
Neochonetes sp.				
Lissochonetes sp.				
Reticulatia sp.				
Rhipidomella sp.				
Neospirifer sp.	6		1	
Productid fragments	31	15	10	
Brachiopod fragments		50	58	85
Molluscs				
Bivalve fragments	6			
Myalinid fragments				
Gastropods				
Loxonematids				
Arthropods				
Smooth ostracodes				5
Ornamented ostracodes				
Trilobite debris				
Barnacle plates				
Echinoderms				
Crinoid debris	10		5	
Echinoid debris		5	3	
Ophiuroid? ossicles		1		
Holothurian sieve plates				
Fish debris				
Conodonts				
Burrow fillings				
Worm tubes				

#	genus	long dem.	short dem.	orient	art	val	frag	epis	type pres	del
1	ech	0.7	0.5	p/					o	

2 pieces of echinoid jaws

BR-3-4

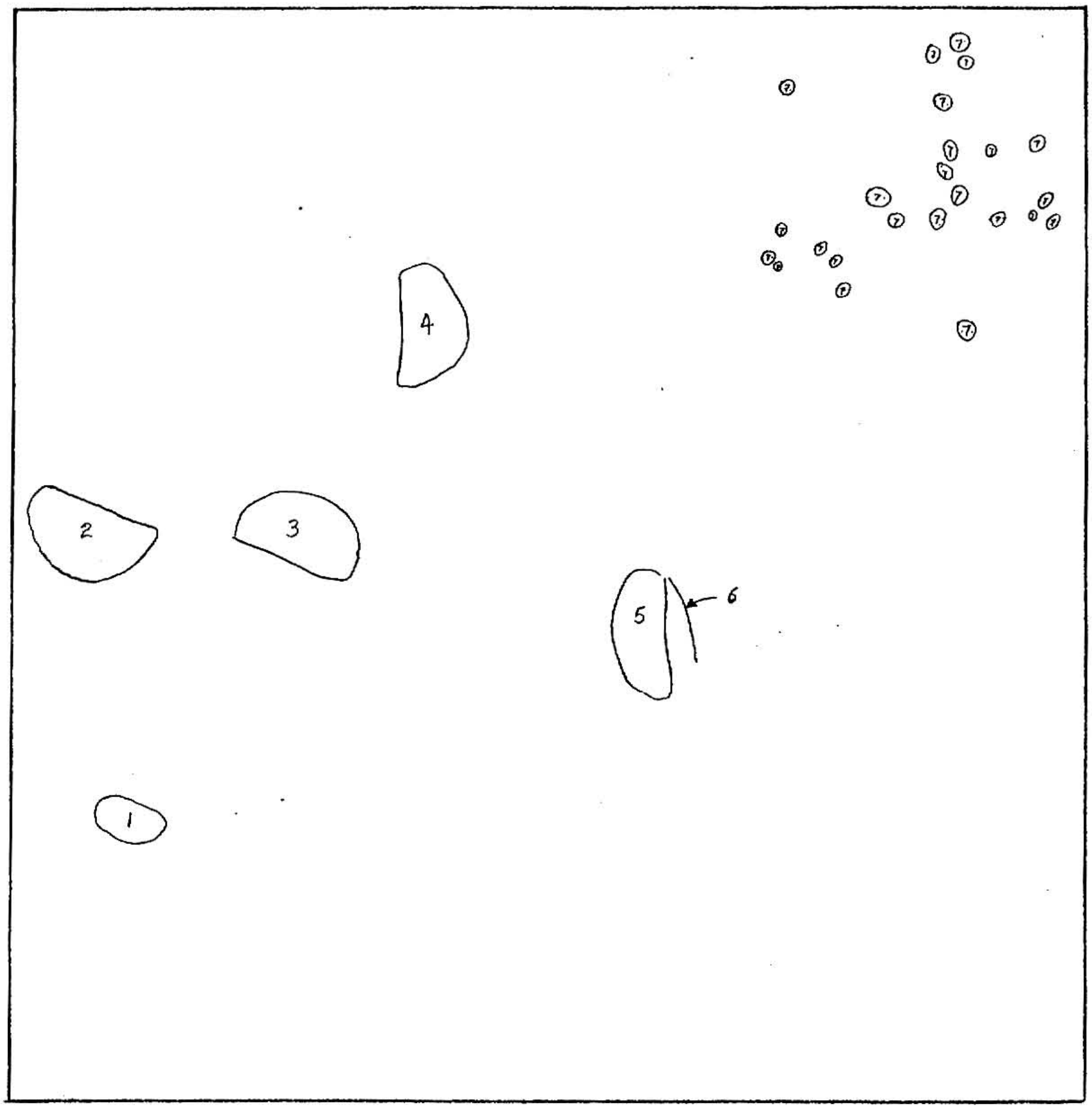


MICROFOSSIL RESIDUE — SAMPLE NUMBER BR - 3 - 4

Taxonomic Entities	Visual Percent Retained on Mesh Sieve			
	+10	+18	+32	+60
Foraminiferids				
Ammobaculites sp.				
Ammodiscus sp.				
Textularids				4
Fusulinids				
Ectoprocts				
Ramose 1	40	30		
Ramose 2	25	4		
Ramose 3				
Fenestrate 1		3	20	
Fenestrate 2	10	6		
Brachiopods				
Inarticulate				
Lingula sp.				
Orbiculoidea sp.				
Petrocrania sp.				
Articulate				
Wellerella sp.				
Crurithyris sp.	25	15	5	4
Derbyia sp.				
Meekella sp.				
Neochonetes sp.				
Lissochonetes sp.				
Reticulatia sp.				
Rhipidomella sp.				
Hustedia sp.				
Productid fragments				
Brachiopod fragments		40	74	80
Molluscs				
Bivalve fragments				
Myalinid fragments				
Gastropods				
Loxonematids				
Arthropods				
Smooth ostracodes				4
Ornamented ostracodes				
Trilobite debris				
Barnacle plates				
Echinoderms				
Crinoid debris				8
Echinoid debris		2	1	
Ophiuroid? ossicles				
Holothurian sieve plates				
Fish debris				
Conodonts				
Burrow fillings				
Worm tubes				

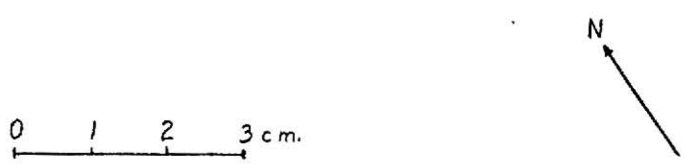
#	genus	long dem.	short dem.	orient	art	val	frag	epis	type pres	del
1	Cru	0.6	0.5	p/cvu	c	p			o	
2	Nech	1.8	1.0	p/ccu		b			o	
3	Nech	1.8	0.9	i/ccu		p			m	
4	Nech	1.5	0.8	i/cvu		b			m	
5	Nech	1.7	0.8	i/cvu		b			m	
6	Nech	1.3	0.6	i/cvu		p			o	
7	bur	0.2	0.1							

BR-3-5



D = 0.810

E = 0.999



MICROFOSSIL RESIDUE SAMPLE NUMBER BR - 3 - 5

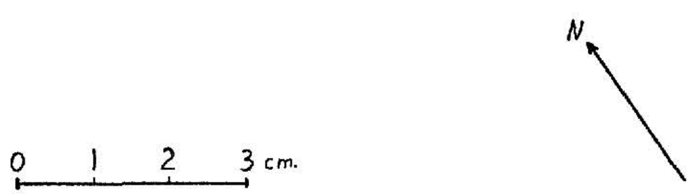
Taxonomic Entities	Visual Percent Retained on Mesh Sieve			
	+10	+18	+32	+60
Foraminiferids				
Ammobaculites sp.				tr
Ammodiscus sp.				tr
Textularids				
Fusulinids				tr
Ectoprocts				
Ramose 1			tr	tr
Ramose 2				
Ramose 3				
Fenestrate 1		5	4	1
Fenestrate 2				tr
Brachiopods				
Inarticulate				
Lingula sp.				
Orbiculoidea sp.				
Petrocrania sp.				
Articulate				
Wellerella sp.				
Crurithyris sp.	80	12	6	2
Derbyia sp.				
Meekella sp.				
Neochonetes sp.			tr	
Lissochonetes sp.				
Reticulatia sp.				
Rhipidomella sp.				
Hustedia sp.				
Productid fragments				
Brachiopod fragments		45	50	50
Molluscs				
Bivalve fragments				
Myalinid fragments				
Gastropods				
Loxonematids				
Arthropods				
Smooth ostracodes			2	10
Ornamented ostracodes			tr	1
Trilobite debris		3	1	tr
Barnacle plates				
Echinoderms				
Crinoid debris		5	8	3
Echinoid debris		5	3	1
Ophiuroid? ossicles			tr	tr
Holothurian sieve plates				
Fish debris			tr	
Conodonts				
Burrow fillings				
Worm tubes				
Matrix and unidentified fragments	20	25	25	32

#	genus	long dem.	short dem.	orient	art	val	frag	epis	type pres	del
1	Orb	0.5	0.3	i/cvu			x		o	
2	Ling	0.9	0.5	p/ccu		?			o	
3	Ling	0.4	0.3	i/		?	x		o	
4	Cru	0.9	0.8	p/cvu		p			o	
5	Cru	0.9	0.9	p/ccu		p			o	
6	Cru	1.0	0.9	p/cvu		p			o	
7	Cru	0.7	0.7	p/cvu		p			o	
8	Ling	0.6	0.3	i/		?	x		o	
9	Cru	0.7	0.5	i/cvu		b			o	
10	Orb	0.5	0.4	p/cvu		p	x		o	
11	bur	1.1	0.2	p/					lim	
12	Orb	0.6	0.6	i/cvu		p	x		o	
13	Cru	0.6	0.6	p/cvu		p			o	
14	Orb	0.5	0.1	p/ccu		?	x		o	
15	brac	0.4	0.2	p/ccu		?	x		o	
16	Cru	0.6	0.4	p/ccu		p			o	
17	Cru	0.6	0.5	p/cvu		p			o	
18	Cru	0.9	0.5	i/cvu		b			o	
19	Cru	0.9	0.9	p/cvu		p			o	
20	Cru	0.9	0.8	p/ccu		p			m	
21	fi de	0.5	0.1						o	

BR-4b-1

D = 1.558

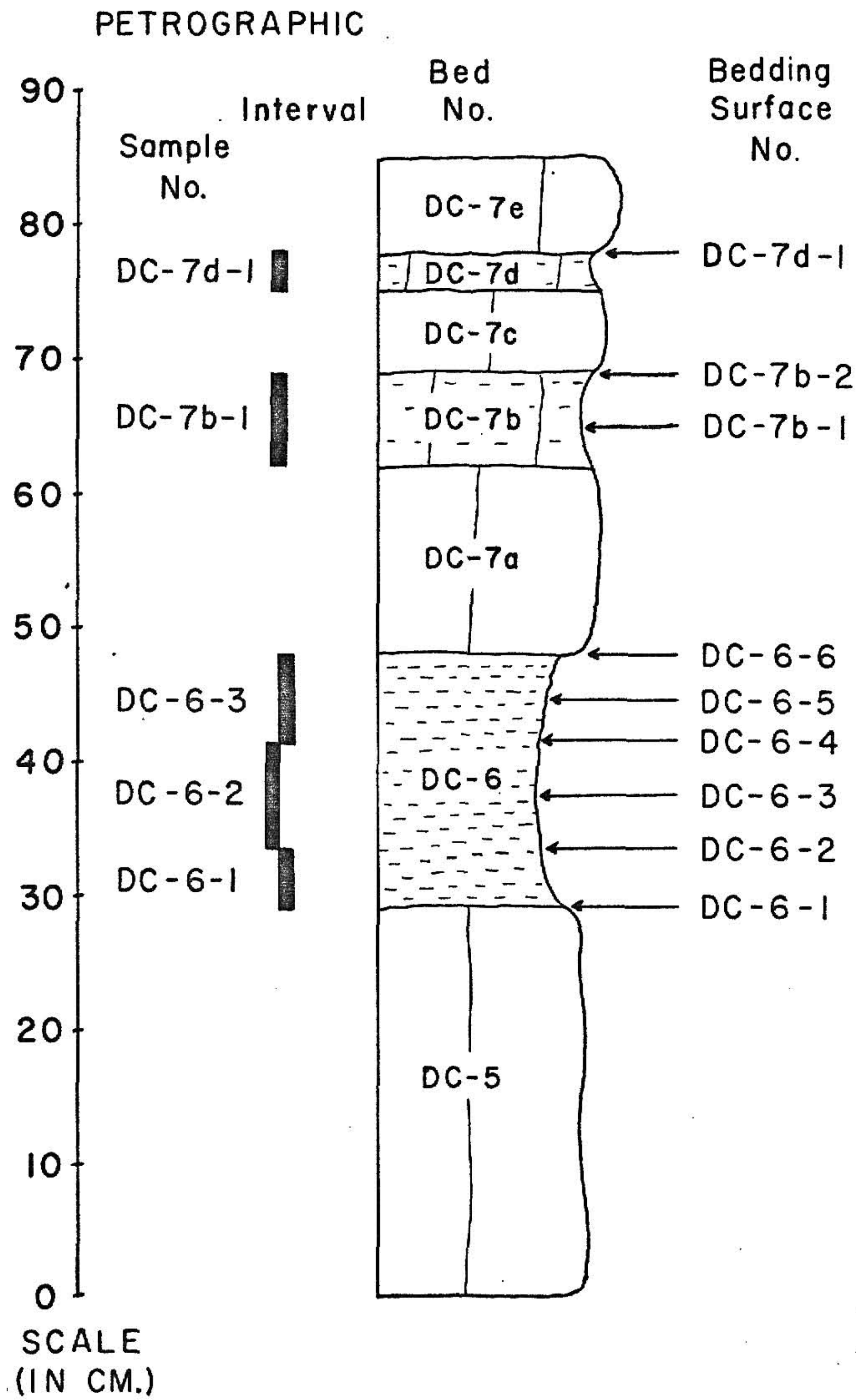
E = 0.932



MICROFOSSIL RESIDUE SAMPLE NUMBER BR - 4b - 1

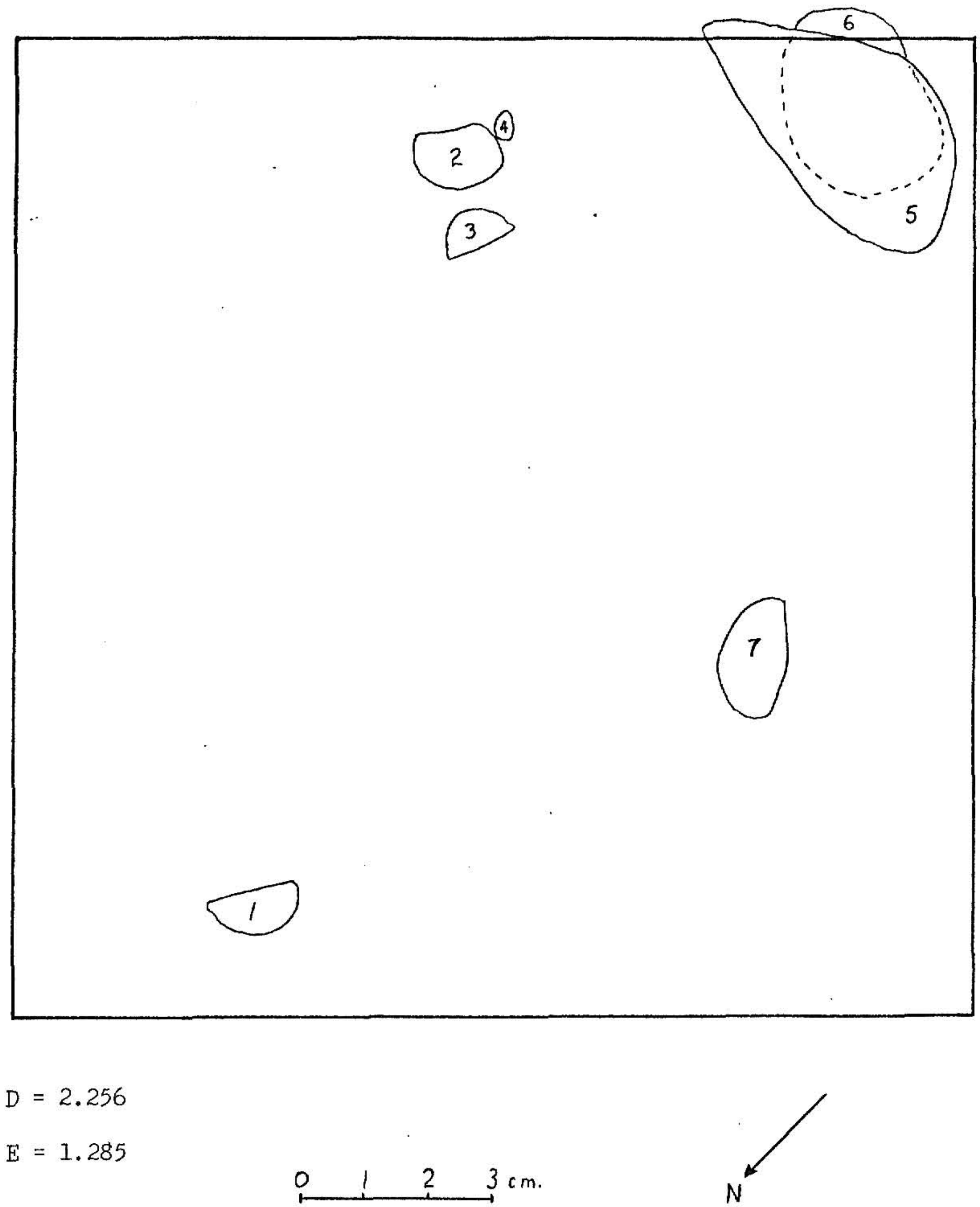
Taxonomic Entities	Visual Percent Retained on Mesh Sieve +10	+18	+32	+60
Foraminiferids				
Ammobaculites sp.				1
Ammodiscus sp.				3
Textularids				
Fusulinids				
Ectoprocts				
Ramose 1				
Ramose 2				
Ramose 3				
Fenestrate 1				
Fenestrate 2			1	
Brachiopods				
Inarticulate				
Lingula sp.			1	2
Orbiculoidea sp.				
Petrocrania sp.				
Articulate				
Wellerella sp.				
Crurithyris sp.	85	7	2	
Derbyia sp.				
Meekella sp.				
Neochonetes sp.				
Lissochonetes sp.	1			
Reticulatia sp.				
Rhipidomella sp.	3	3		
Hustedia sp.				
Productid fragments				
Brachiopod fragments	10	87	90	88
Molluscs				
Bivalve fragments				
Myalinid fragments				
Gastropods				
Loxonematids				
Arthropods				
Smooth ostracodes			3	3
Ornamented ostracodes				
Trilobite debris				
Barnacle plates				
Echinoderms				
Crinoid debris	1	3	2	
Echinoid debris			1	2
Ophiuroid? ossicles				
Holothurian sieve plates				
Fish debris				
Conodonts			tr	tr
Burrow fillings				
Worm tubes				1

DEEP CREEK (DC) SECTION



#	genus	long dem.	short dem.	orient	art	val	frag	epis	type pres	del
1	Nech	1.5	0.8	p/ccu	c				o	
2	Cru	0.8	0.7	p/cvu		p			o	
3	Meek	1.0	0.8	p/cvu		?	x	rbry	o	
4	brac	0.7	0.6	i/cvu		?	x		o	
5	Nesp	5.0	3.6	p/ccu		b			o	
6	Ret	3.8	1.6	i/		p	x		o	
7	Nech	1.6	0.9	p/ccu	c				o	

DC-6-1

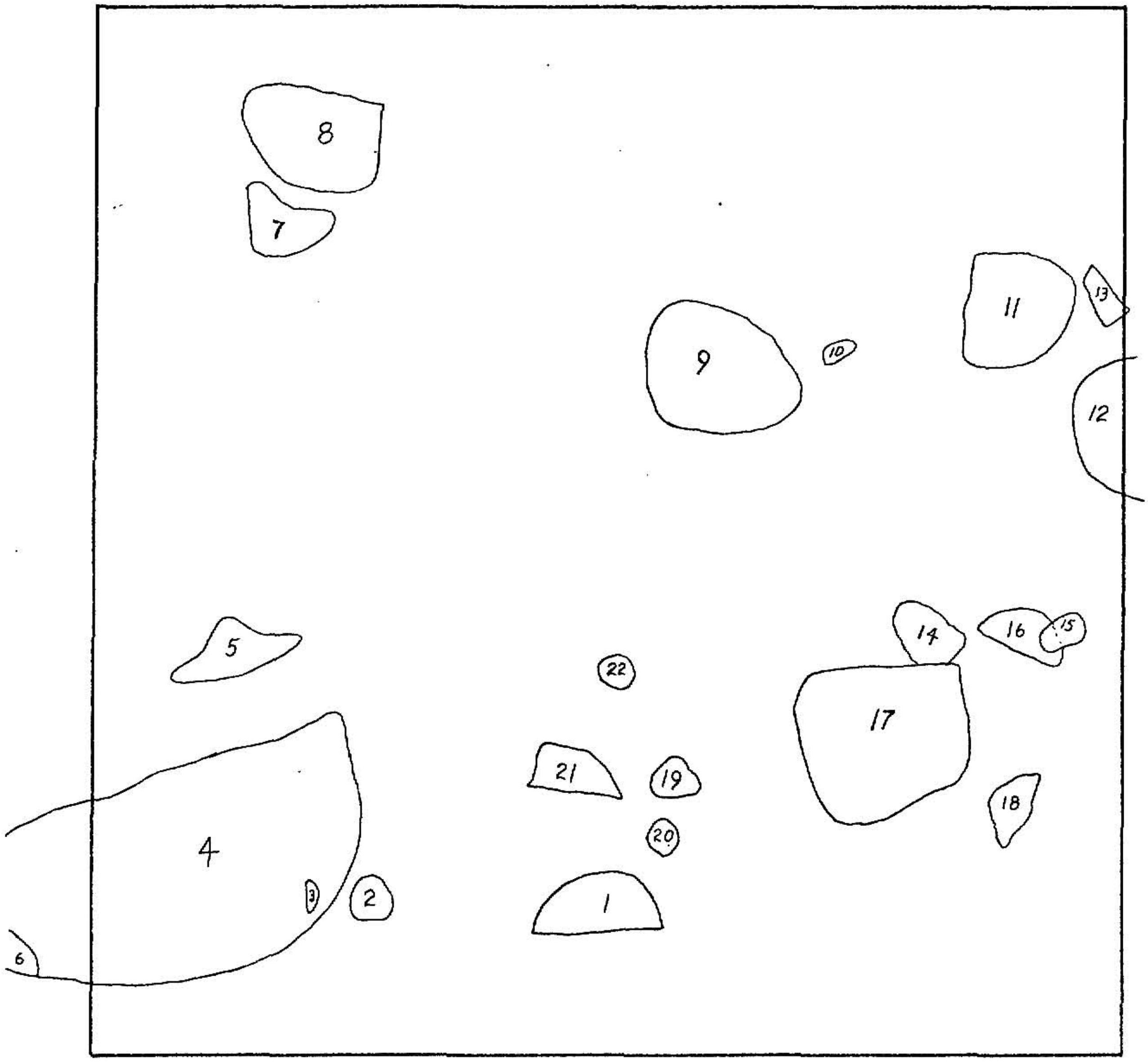


D = 2.256

E = 1.285

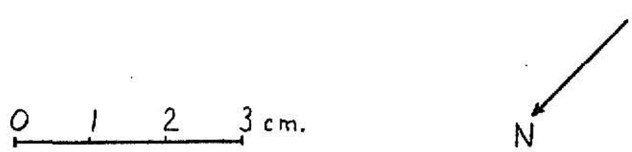
#	genus	long dem.	short dem.	orient	art	val	frag	epis	type pres	del
1	Nech	1.7	0.9	p/ccu	c				o	
2	Cru	0.4	0.4	p/ccu		b			o	
3	brac	0.5	0.3	p/ccu		b	x		o	
4	Myl	6.6	3.5	p/cvu		?		rbry	o	
5	Nesp	3.2	1.2	p/cvu		p	x		o	
6	r I	0.7	0.5	p/zeu				(4)	o	
7	prod	1.3	0.8	p/ccu		p	x		o	
8	prod	1.5	1.3	p/ccu		p	x		o	
9	Lino	2.3	1.9	p/cvu		p			o&m	
10	brac	0.8	0.3	i/			x		o	
11	Ret	1.8	1.6	p/cvu		b			o	
12	Ret	2.7	2.5	p/cvu		p			o	
13	f I	0.7	0.3	p/					o	
14	Comp	1.7	1.3	p/cvu		p			o	
15	Cru	0.6	0.6	p/cvu		p			o	
16	Nech	1.2	0.7	p/cvu		p			o	
17	f I	3.1	2.3	p/zeu					o	
18	Lino	1.3	1.1	p/cvu		p			o	
19	Comp	0.7	0.6	p/cvu		p			o	
20	brac	0.3	0.3	i/cvu			x		o	
21	Nesp	1.2	0.5	i/			x		o	
22	Cru	0.7	0.6	p/cvu	c	p			o	

DC-6-2



D = 2.731

E = 1.022

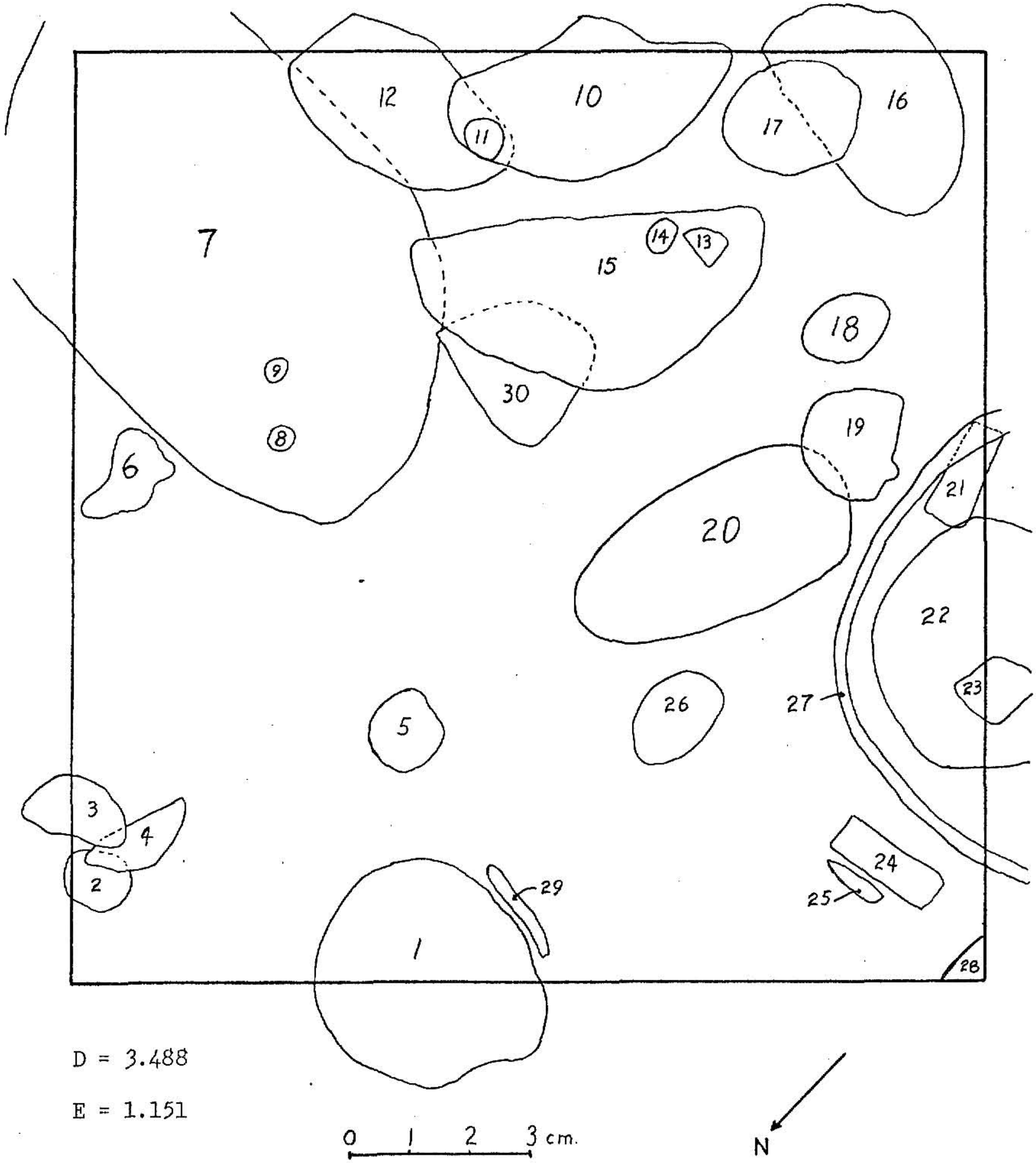


MICROFOSSIL RESIDUE SAMPLE NUMBER DC - 6 - 2

Taxonomic Entities	Visual Percent Retained on Mesh Sieve			
	+10	+18	+32	+60
Foraminiferids				
Ammobaculites sp.				
Ammodiscus sp.				
Textularids				
Fusulinids				
Ectoprocts				
Ramose 1	5	2		
Ramose 2	1	1	1	
Ramose 3	1			
Fenestrate 1		1	1	
Fenestrate 2	3	2	1	1
Brachiopods				
Inarticulate				
Lingula sp.				
Orbiculoidea sp.				
Petrocrania sp.	3			
Articulate				
Wellerella sp.				
Crurithyris sp.	20	25	7	
Derbyia sp.	5			
Meekella sp.				
Neochonetes sp.	20	1		
Lissochonetes sp.				
Reticulatia sp.				
Rhipidomella sp.				
Hustedia sp.				
Productid fragments	25	35	15	25
Brachiopod fragments	12	25	61	65
Molluscs				
Bivalve fragments			3	
Myalinid fragments				
Gastropods				
Loxonematids				
Arthropods				
Smooth ostracodes				3
Ornamented ostracodes				tr
Trilobite debris				
Barnacle plates				
Echinoderms				
Crinoid debris	2	3	10	5
Echinoid debris	3	5	1	1
Ophiuroid? ossicles				
Holothurian sieve plates				
Fish debris				tr
Conodonts				
Burrow fillings				
Worm tubes				

#	genus	long dem.	short dem.	orient	art	val	frag	epis	type pres	del
1	Derb	4.2	3.7	p/cvu		?	x		o	
2	Well	1.1	1.0	p/cvu		p			o	
3	Nech	1.6	0.8	p/cvu		p	x		o	
4	Ret	1.7	0.7	p/		p	x	Pet	o	
5	uBv	1.1	1.0	p/		?	x	r I	o	
6	Ret	1.5	1.3	p/ccu		b	x		o	
7	f II	8.8	6.5	p/cvu				(8&9)	o	
8	Pet	0.3	0.3	p/cvu		p		(7)	o	
9	Pet	0.3	0.3	p/cvu		p		(7)	o	
10	Nesp	4.9	2.4	p/cvu		b		(11)	o	
11	Pet	0.6	0.6	p/cvu		p		(10)	o	
12	Nesp	4.8	2.8	p/cvu		p			o	
13	Cru	0.9	0.8	p/cvu		p			o	
14	Pet	0.5	0.5	p/cvu		p		(15)	o	
15	Nesp	4.8	2.6	p/cvu		b		(14)	o	
16	Ret	3.8	2.7	p/cvu	c	p			o	
17	Comp	2.4	1.8	p/cvu		p			o	
18	f I	1.1	0.9	p/ccu					o	
19	Ret	1.8	1.4	p/cvu		b			o	
20	Wilk	4.3	2.6	p/cvu		r			m	
21	crin	1.6	0.6						o	
22	Ret	4.1	3.8	p/cvu		p			o	
23	Nech	2.0	1.0	p/cvu		p			o	
24	crin	1.4	0.6	p/					o	
25	brac	1.9	0.6	i/			x		o	
26	Sch	1.8	1.3	p/cvu		l			m&o	
27	Ret	7.3	5.1	p/cvu		p			o	
28	Ret	4.3	3.8	p/cvu		p	x		o	
29	r III	1.7	1.4	i/					o	
30	Nesp	2.9	2.2	p/cvu		p	x		o	

DC-6-3



D = 3.488

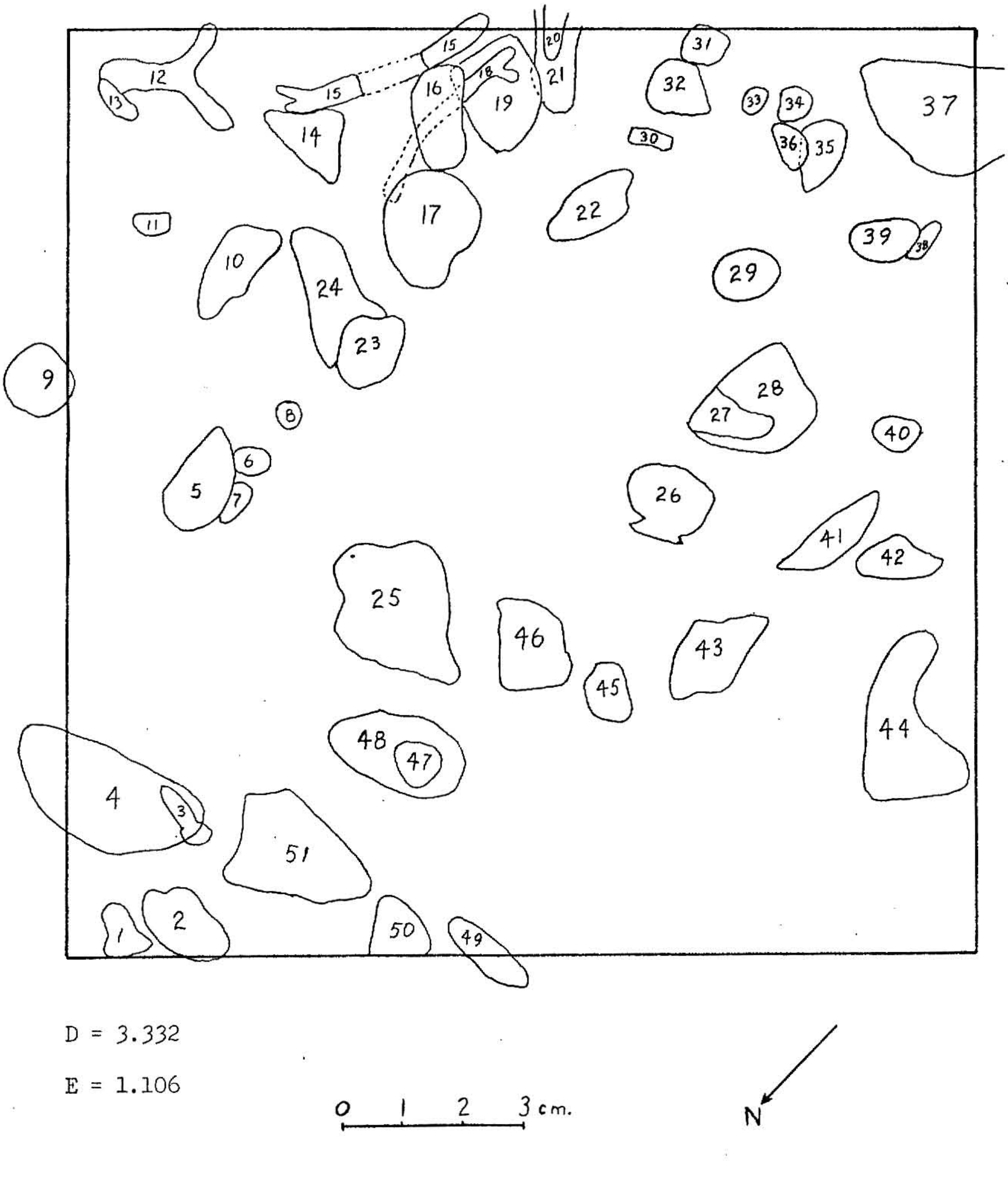
E = 1.151

MICROFOSSIL RESIDUE — SAMPLE NUMBER DC - 6 - 3

Taxonomic Entities	Visual Percent Retained on Mesh Sieve			
	+10	+18	+32	+60
Foraminiferids				
Ammobaculites sp.				
Ammodiscus sp.				
Textularids				
Fusulinids				
Ectoprocts				
Ramose 1	10	3		
Ramose 2			1	
Ramose 3	13			
Fenestrate 1		3	1	
Fenestrate 2		5	3	1
Brachiopods				
Inarticulate				
Lingula sp.				
Orbiculoidea sp.				
Petrocrania sp.	12	tr		
Articulate				
Wellerella sp.				
Crurithyris sp.	15	8	5	1
Derbyia sp.		3		
Meekella sp.				
Neochonetes sp.				
Lissochonetes sp.				
Reticulatia sp.				
Rhipidomella sp.				
Neospirifer sp.	5	tr		
Productid fragments	25	15	15	20
Brachiopod fragments		48	70	64
Molluscs				
Bivalve fragments	12	7		
Myalinid fragments				
Gastropods				
Loxonematids				
Arthropods				
Smooth ostracodes			tr	12
Ornamented ostracodes				1
Trilobite debris				
Barnacle plates				
Echinoderms				
Crinoid debris	8	1	3	1
Echinoid debris		5	1	tr
Ophiuroid? ossicles		2	1	
Holothurian sieve plates				
Fish debris				
Conodonts				
Burrow fillings				
Worm tubes				

#	genus	long dem.	short dem.	orient	art	val	frag	epis	type pres	del
1	f I	1.2	0.6	p/ccu			x		o	x
2	f II	1.6	0.7	p/			x		o	x
3	r IV	1.7	0.4	i/			x	prod	o	
4	Wilk	3.4	1.7	i/	c				m	
5	Ret	1.4	1.0	i/ccu		?	x	(7)	o	
6	f II	1.2	0.4	p/			x		o	
7	r IV	0.9	0.5	i/				(5)	o	
8	f II	0.7	0.5	i/			x		m	x
9	Well	1.0	0.8	p/cvu	c				o	
10	r I	1.9	0.7	p/					o	
11	brac	0.8	0.8	p/			x	(12)	o	
12	r II	2.4	0.3	i/				(11)	o	x
13	f II	0.8	0.8	i/					o	x
14	Ptsp	1.6	1.0	p/cvu		p			o	
15	r II	3.2	0.2	p/					o	x
16	f I	1.7	1.0	i/					o	x
17	Lino	2.1	1.7	p/ccu	c				o	
18	r I	1.3	0.2	i				brac	o	x
19	Apec	1.7	1.6	p/ccu		?	x		o	
20	fI	0.9	0.3	p/			x		o	
21	Pter?	2.7	0,8	p/ccu		?	x		m&o	
22	Ret	1.4	1.3	p/ccu	c		x		o	
23	Ret	1.1	0.9	p/ccu		b			o	
24	Nesp	2.3	1.1	p/ccu		?	x		o	
25	Nesp	2.2	1.5	p/cvu		?	x		o	
26	Apec	1.8	1.3	p/cvu		?	x		o	
27	f II	1.5	0.8	p/					o	
28	f I	2.0	1.4	i/ccu					o	x
29	brac	0.6	0.6	p/cvu		?	x		o	
30	r II	0.7	0.1	i/					o	
31	Lino	0.8	0.4	p/ccu		?	x		o	
32	Lino	1.2	1.0	p/ccu		p	x		o	
33	brac	0.6	0.4	p/ccu		?	x		o	
34	Ret	0.7	0.6			?	x		o	
35	Nesp	0.6	0.2	i/		?	x		o	
36	f I	0.5	0.3						o	x
37	Nesp	4.7	1.8	i/cvu		b			o	
38	f II	0.5	0.4	p/			x		o	
39	f II	1.0	0.8	p/					o	x
40	r IV	0.8	0.3				x		o	
41	Wilk	2.1	0.7	i/cvu	c				m&o	
42	Ret	1.3	0.7	p/ccu		p	x		o	
43	Nesp	1.9	1.0	p/ccu		p	x		o	
44	f II	2.7	1.6	i/					o	x
45	Myl	0.9	0.6	i/		?	x	f II	o	
46	Myl	1.6	1.2	p/		?	x		o	
47	brac	1.1	0.9	i/ccu			x		o	
48	f II	2.1	1.1	i/					o	x
49	Wilk	1.5	0.5	i/cvu	c				m	
50	Ret	1.0	0.6	i/cvu			x		o	
51	f II	2.7	1.5	i/					o	x

DC-6-4



D = 3.332

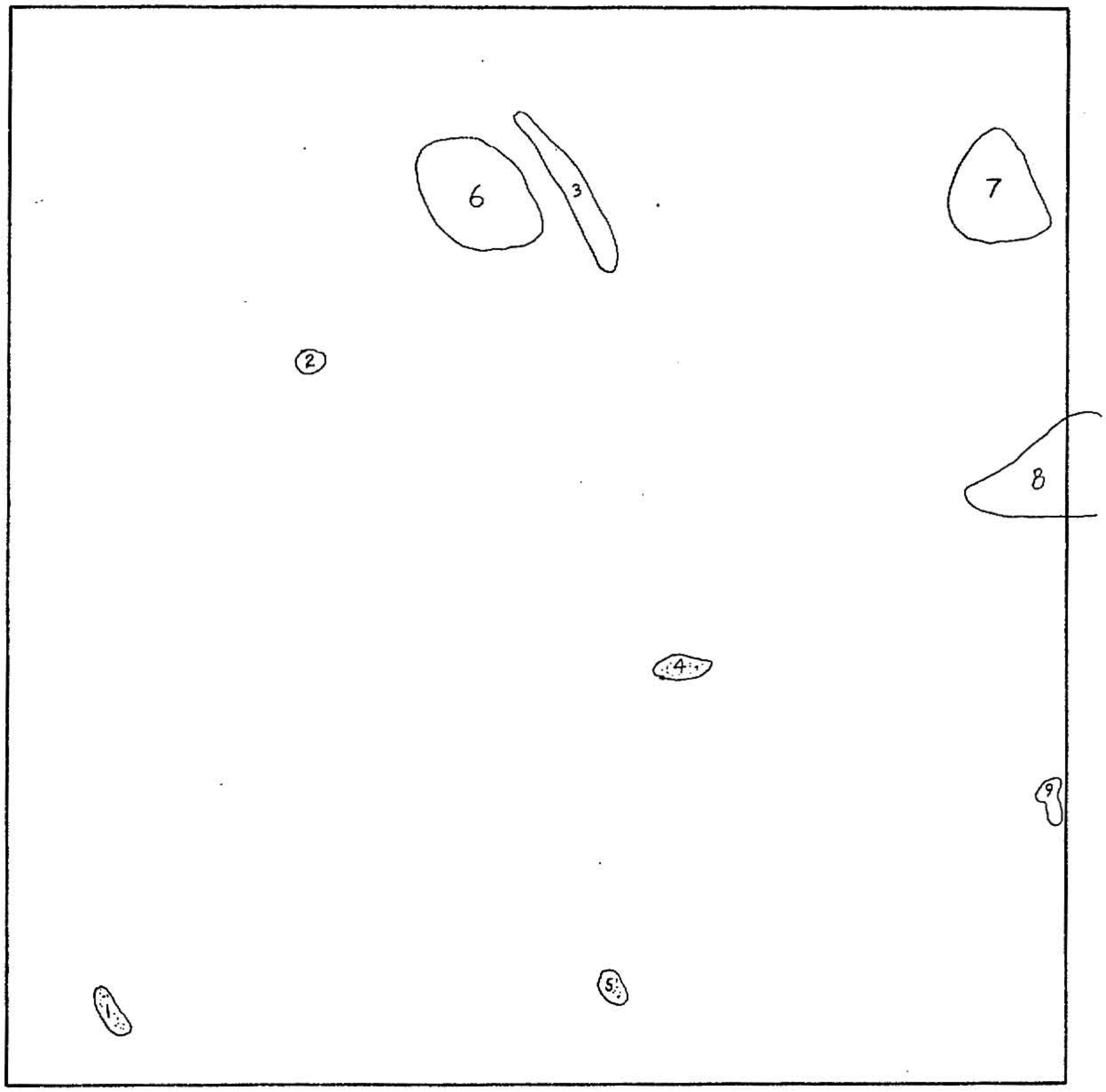
E = 1.106

MICROFOSSIL RESIDUE — SAMPLE NUMBER DC - 6 - 4

Taxonomic Entities	Visual Percent Retained on Mesh Sieve			
	+10	+18	+32	+60
Foraminiferids				
Ammobaculites sp.				
Ammodiscus sp.				
Textularids				1
Fusulinids				
Ectoprocts				
Ramose 1	20	4	5	
Ramose 2				
Ramose 3				
Fenestrate 1	10	30	20	10
Fenestrate 2	7	3	10	
Brachiopods				
Inarticulate				
Lingula sp.				
Orbiculoidea sp.				
Petrocrania sp.	15	6	2	
Articulate				
Wellerella sp.				
Crurithyris sp.	7	5	5	3
Derbyia sp.				
Meekella sp.				
Neochonetes sp.			1	
Lissochonetes sp.				
Reticulatia sp.	20	2		
Rhipidomella sp.				
Neospirifer sp.				
Productid fragments		4	7	5
Brachiopod fragments		38	40	67
Molluscs				
Bivalve fragments		2		
Myalinid fragments				
Gastropods				
Loxonematids				
Arthropods				
Smooth ostracodes			1	8
Ornamented ostracodes				3
Trilobite debris				
Barnacle plates				
Echinoderms				
Crinoid debris	6		5	2
Echinoid debris		1	3	
Ophiuroid? ossicles			1	1
Holothurian sieve plates				
Fish debris				tr
Conodonts				
Burrow fillings				
Worm tubes				

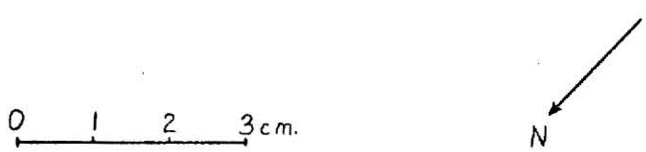
#	genus	long dem.	short dem	orient	art	val	frag	epis	type pres	del
1	bur	0.4	0.2	i/					lim	
2	crin	0.2	0.2	i/					o	
3	prod	2.3	1.2	i/ccu		b	x		o	
4	bur	0.6	0.2	i/					lim.	
5	bur	3.1	0.1	i/						
6	Jur	2.5	0.8	p/cvu		p	x		o	
7	Nesp	1.7	0.7	p/cvu		p	x		o	
8	Pter	4.1	1.4	i/	c				o	
9	r IV	1.1	0.3	i/					o	

DC-6-5



D = 2.591

E = 1.382

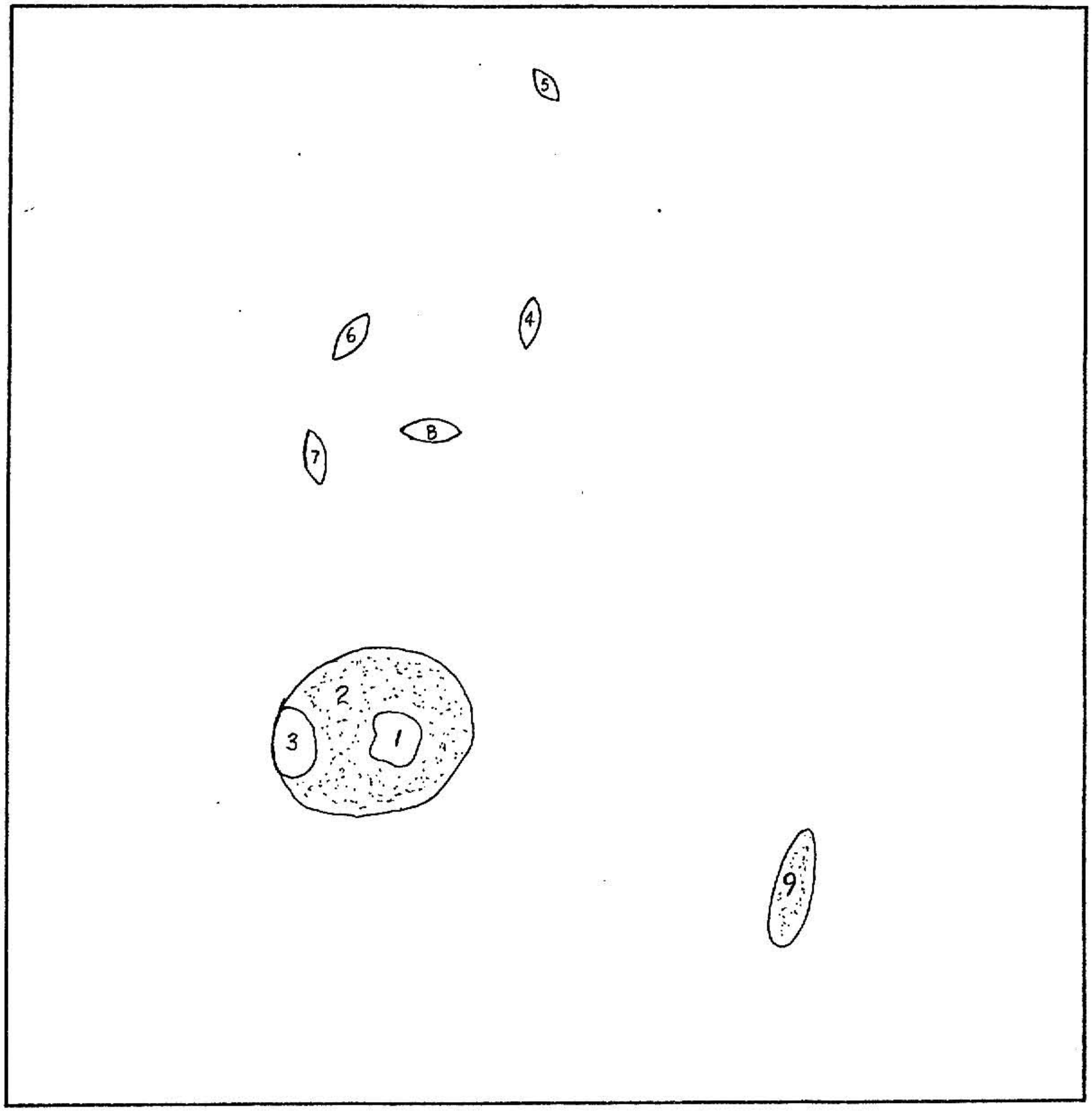


MICROFOSSIL RESIDUE — SAMPLE NUMBER DC - 6 - 5

Taxonomic Entities	Visual Percent Retained on Mesh Sieve			
	+10	+18	+32	+60
Foraminiferids				
Ammobaculites sp.				
Ammodiscus sp.				
Textularids				1
Fusulinids				
Ectoprocts				
Ramose 1	15	5		
Ramose 2				
Ramose 3	20	15	1	
Fenestrate 1		5	7	
Fenestrate 2	15	30	15	4
Brachiopods				
Inarticulate				
Lingula sp.				
Orbiculoidea sp.				
Petrocrania sp.	7			
Articulate				
Wellerella sp.				
Crurithyris sp.		2	5	5
Derbyia sp.				
Meekella sp.				
Neochonetes sp.				
Lissochonetes sp.				
Reticulatia sp.				
Rhipidomella sp.				
Hustedia sp.				
Productid fragments	20	10	3	30
Brachiopod fragments		30	58	48
Molluscs				
Bivalve fragments		1	2	3
Myalinid fragments	20			
Gastropods				
Loxonematids				
Arthropods				
Smooth ostracodes			4	3
Ornamented ostracodes			1	1
Trilobite debris		1		
Barnacle plates			1	1
Echinoderms				
Crinoid debris	3	5	2	5
Echinoid debris			2	
Ophiuroid? ossicles				
Holothurian sieve plates				
Fish debris				
Conodonts				
Burrow fillings				
Worm tubes				

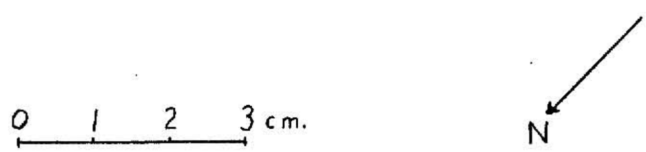
#	genus	long dem.	short dem.	orient	art	val	frag	epis	type pres	del
1	Cru	0.8	0.7	p/ccu		p			o	
2	bur	2.0	2.0	i/						
3	Well	0.9	0.8	i/	c				o	
4	fus	0.7	0.2	i/					o	
5	fus	0.7	0.2	i/					o	
6	fus	0.6	0.2	p/					o	
7	fus	0.8	0.3	i/					o	
8	fus	0.7	0.2	p/					o	
9	bur	1.7	0.3	p/					lim	

DC-6-6



D = 1.149

E = 0.897

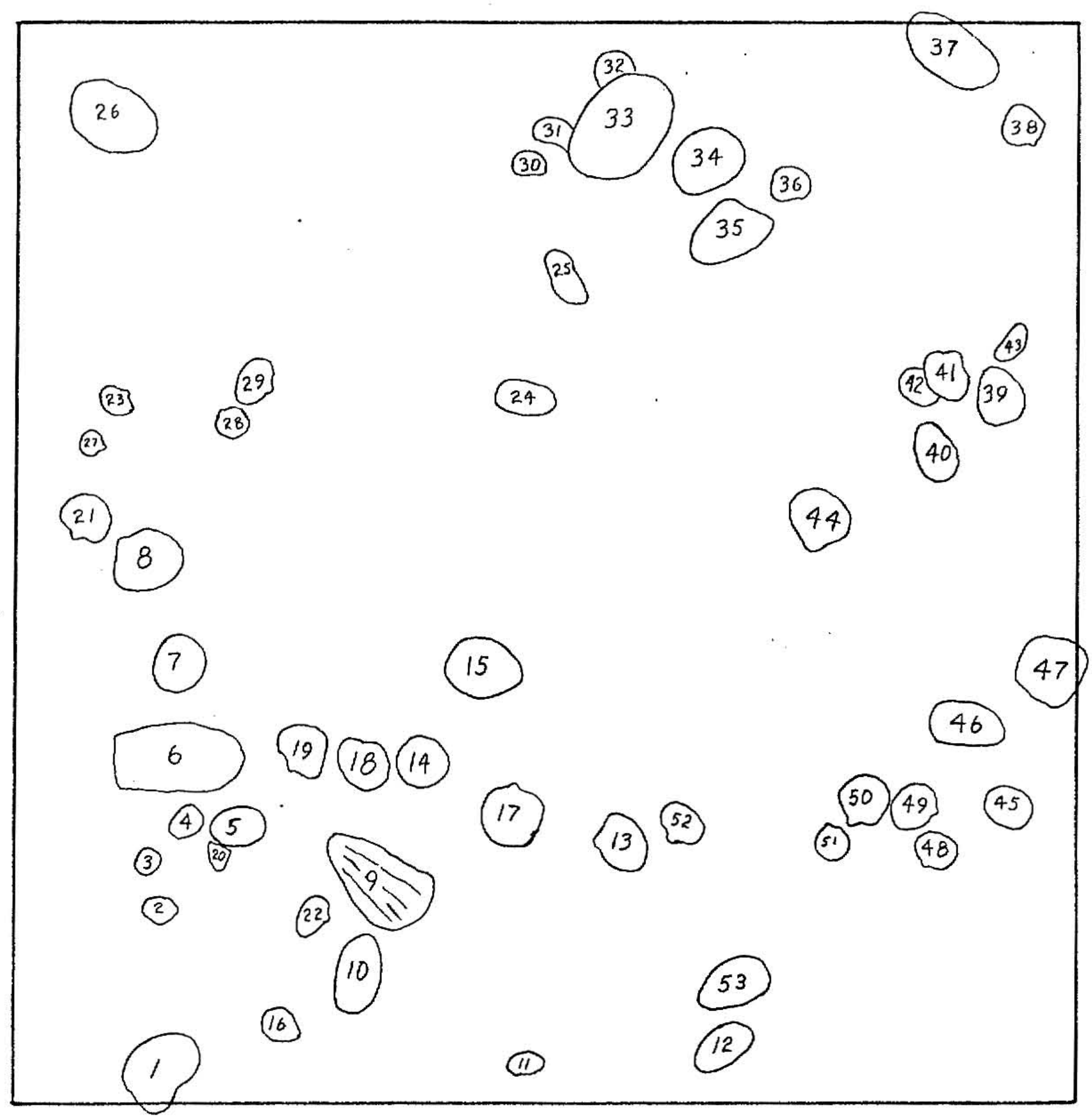


MICROFOSSIL RESIDUE SAMPLE NUMBER DC - 6 - 6

Taxonomic Entities	Visual Percent Retained on Mesh Sieve			
	+10	+18	+32	+60
Foraminiferids				
Ammobaculites sp.				
Ammodiscus sp.				1
Textularids				
Fusulinids	20		1	
Ectoprocts				
Ramose 1				
Ramose 2				
Ramose 3				
Fenestrate 1	10	15	5	
Fenestrate 2				
Brachiopods				
Inarticulate				
Lingula sp.				
Orbiculoidea sp.				
Petrocrania sp.				
Articulate				
Wellerella sp.				
Crurithyris sp.	10	20		
Derbyia sp.				
Meekella sp.				
Neochonetes sp.				
Lissochonetes sp.				
Reticulatia sp.				
Rhipidomella sp.				
Hustedia sp.				
Productid fragments	10			
Brachiopod fragments	50	60	76	86
Molluscs				
Bivalve fragments				
Myalinid fragments				
Gastropods				
Loxonematids				
Arthropods				
Smooth ostracodes			10	7
Ornamented ostracodes			1	1
Trilobite debris			1	
Barnacle plates				
Echinoderms				
Crinoid debris		5	5	3
Echinoid debris			1	2
Ophiuroid? ossicles				
Holothurian sieve plates				
Fish debris				tr
Conodonts				tr
Burrow fillings				
Worm tubes				

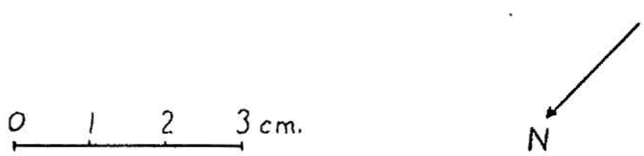
#	genus	long dem.	short dem.	orient	art	val	frag	epis	type pres	del
1	Ling	1.7	0.9	p/cvu		?			o	
2	Cru	0.4	0.4	p/ccu		p			m	
3	Cru	0.3	0.3	p/cvu	c	p			o	
4	Cru	0.6	0.5	p/cvu		p			o	
5	Cru	0.9	0.7	p/cvu		p			o	
6	Vol	2.3	1.2	p/cvu		l			o	
7	Cru	0.6	0.6	p/ccu		p			m	
8	Cru	1.0	1.0	p/cvu		p			o	
9	Pina	2.1	1.0	p/cvu		r?			m	
10	Ling	0.9	0.7	p/cvu		?			o	
11	Cru	0.3	0.3	p/ccu	c	p			o	
12	Cru	0.6	0.6	p/ccu		p			m	
13	Cru	1.0	0.8	p/cvu		p			o	
14	Cru	0.6	0.6	p/ccu		p			m	
15	Cru	0.9	0.9	p/ccu		p			m	
16	Cru	1.0	0.9	p/cvu		p			o	
17	Cru	0.8	0.8	p/ccu		p			o	
18	Cru	0.8	0.6	p/ccu		p			m	
19	Cru	1.2	1.1	p/ccu		p			o	
20	Cru	0.5	0.4	p/ccu		p			o	
21	Cru	0.9	0.9	p/cvu		p			o	
22	Cru	1.1	0.8	p/ccu		b			o	
23	Cru	0.4	0.4	p/ccu		p			m	
24	Ling	1.3	0.8	i/ccu		?			o	
25	uBv	0.8	0.6	p/cvu		?	x		m	
26	Ling	1.5	0.9	i/cvu		?			o	
27	Cru	0.8	0.7	p/cvu		p			o	
28	Cru	0.5	0.4	p/ccu		p			m	
29	Cru	0.6	0.5	p/cvu		p			o	
30	Ling	1.6	1.1	p/cvu		?			o	
31	Cru	0.6	0.5	p/ccu		p			m	
32	Cru	0.6	0.5	p/cvu		p			o	
33	Ling	1.6	1.1	p/ccu		?			o	
34	Cru	1.0	0.9	p/ccu		p			m	
35	Cru	1.0	0.9	p/ccu		p			m	
36	Cru	0.5	0.4	p/ccu		p			m	
37	Vol	1.5	0.8	p/ccu		l			o	
38	Cru	0.5	0.4	p/ccu		p			m	
39	Cru	0.9	0.6	p/ccu		p			m	
40	Cru	1.0	0.7	p/cvu		b			o	
41	Cru	0.8	0.8	p/cvu		p			o	
42	Cru	0.8	0.8	p/cvu		p			o	
43	Cru	0.9	0.8	i/cvu		p			o	
44	Ling	1.3	0.8	i/ccu		?			o	
45	Cru	0.6	0.6	p/ccu		p			m	
46	Cru	0.8	0.7	i/cvu		p			o	
47	Cru	1.1	1.0	p/cvu		p			o	
48	Cru	0.6	0.5	p/ccu		p			m	
49	Cru	0.7	0.6	p/ccu		p			m	
50	Cru	0.8	0.6	p/ccu		p			m	
51	Cru	0.5	0.5	p/ccu		b			o	
52	Cru	0.6	0.4	p/ccu		6			o	
53	Ling	1.1	0.6	i/ccu		?			o	

DC-7b-1



D = 0.605

E = 0.582



MICROFOSSIL RESIDUE SAMPLE NUMBER DC - 7b - 1

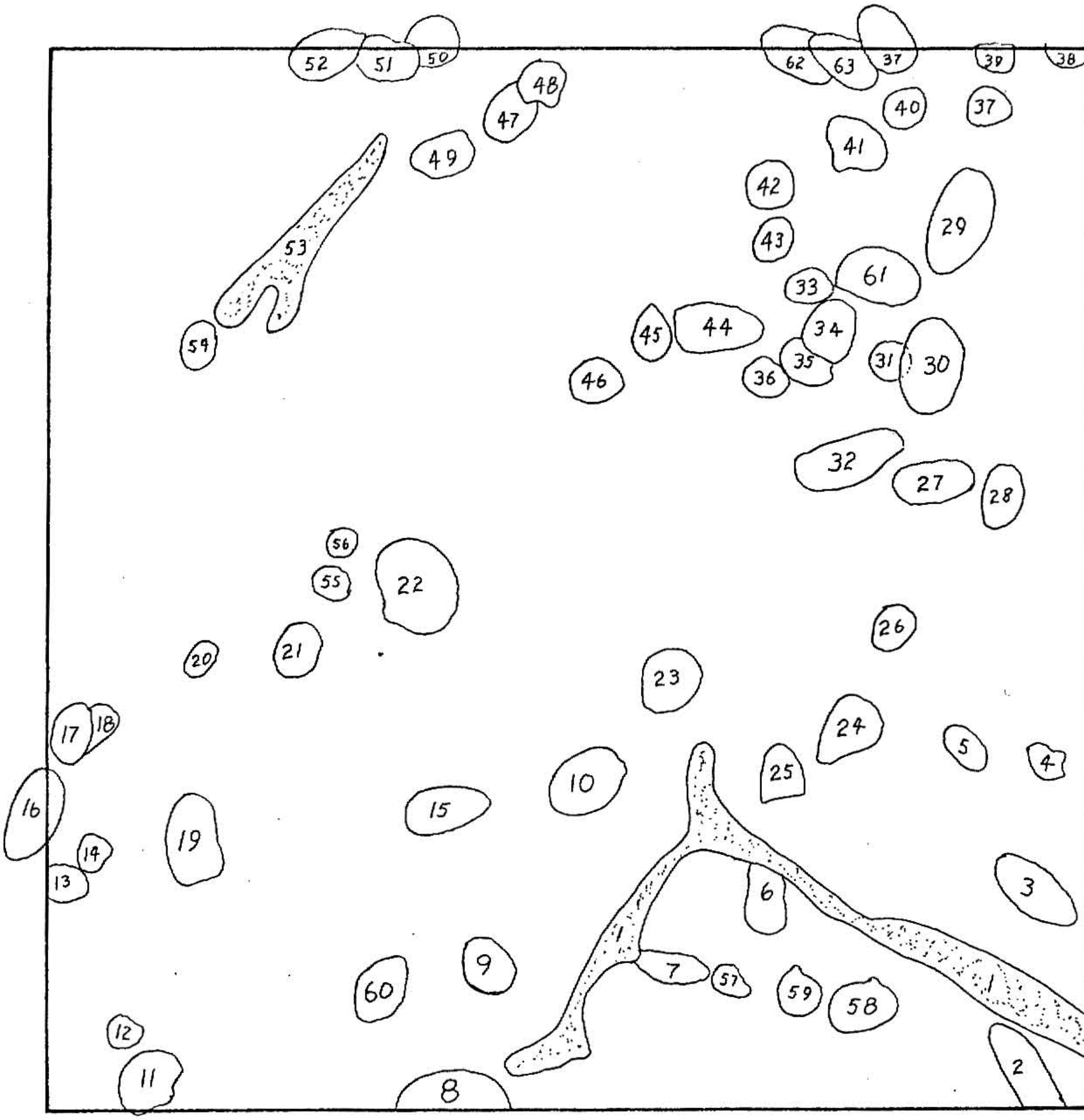
Taxonomic Entities	Visual Percent Retained on Mesh Sieve			
	+10	+18	+32	+60
Foraminiferids				
Ammobaculites sp.				1
Ammodiscus sp.				tr
Textularids				
Fusulinids				
Ectoprocts				
Ramose 1				
Ramose 2				
Ramose 3				
Fenestrate 1				
Fenestrate 2				
Brachiopods				
Inarticulate				
Lingula sp.			1	tr
Orbiculoidea sp.			1	tr
Petrocrania sp.				
Articulate				
Wellerella sp.				
Crurithyris sp.	50	20	1	1
Derbyia sp.				
Meekella sp.				
Neochonetes sp.				
Lissochonetes sp.				
Reticulatia sp.				
Rhipidomella sp.	1	2	tr	
Hustedia sp.				
Productid fragments			2	3
Brachiopod fragments	19	55	63	15
Molluscs				
Bivalve fragments				
Myalinid fragments				
Gastropods				
Loxonematids				tr
Arthropods				
Smooth ostracodes				
Ornamented ostracodes				
Trilobite debris				
Barnacle plates				
Echinoderms				
Crinoid debris		3	2	
Echinoid debris				
Ophiuroid? ossicles				
Holothurian sieve plates				
Fish debris				tr
Conodonts				tr
Burrow fillings				
Worm tubes				
Matrix and unidentified fragments	30	20	30	80

#	genus	long dem.	short dem.	orient	art	val	frag	epis	type pres	del
1	bur	11.6	0.6	p/						
2	Ling	0.9	0.6	p/ccu		?	x		o	
3	Ling	1.3	0.8	p/cvu		?			o	
4	Cru	0.8	0.7	p/cvu		p			o	
5	Cru	0.9	0.9	p/cvu		p			o	
6	Ling	1.2	0.8	p/cvu		?			o	
7	Ling	1.4	0.7	p/cvu		?			o	
8	Ling	1.8	0.9	p/cvu		?			o	
9	Cru	0.8	0.8	p/cvu	c	p			o	
10	uBv	1.2	0.8	p/ccu		r			m	
11	Cru	0.7	0.7	p/cvu		p			o	
12	Cru	0.6	0.6	p/ccu		p			o	
13	Cru	0.8	0.7	p/ccu		b			o	
14	Cru	0.7	0.7	p/ccu		p			o	
15	uBv	1.3	0.8	p/cvu		r			m	
16	Ling	1.3	0.8	p/cvu		?			o	
17	Ling	1.1	0.6	p/ccu		p			o	
18	Ling	1.1	?	p/cvu		b			o	
19	Ling	1.8	0.9	p/ccu		?			o	
20	Cru	0.6	0.6	p/ccu		p			o	
21	Cru	0.8	0.6	p/ccu		b			o	
22	Cru	1.2	1.1	p/ccu	c	p			o	
23	Ling	0.8	0.5	p/cvu		?	x		o	
24	uBv	1.3	0.8	p/ccu		?	x		m	
25	Ling	0.9	0.6	p/cvu		?	x		o	
26	Cru	0.6	0.6	p/cvu		p			o	
27	Ling	1.3	0.7	p/cvu		?			o	
28	Ling	0.9	0.4	p/cvu		?			o	
29	Ling	1.5	0.8	p/ccu		?			o	
30	Ling	1.5	0.7	p/cvu		?			o	
31	Cru	0.5	0.5	p/ccu		p			o	
32	Cru	0.7	0.7	p/ccu		p			o	
33	Cru	0.7	0.7	p/ccu		p			o	
34	Cru	0.6	0.6	p/ccu		p			o	
35	Cru	0.6	0.6	p/ccu		p			o	
36	Cru	0.7	0.7	p/ccu		p			o	
37	Vol	1.1	2.1	p/ccu		r			m	
38	Acan	1.4	1.2	p/ccu		p			o	
39	Cru	0.6	0.6	p/ccu		p			o	
40	Cru	0.6	0.6	p/cvu		p			o	
41	Cru	0.8	0.7	p/ccu	c	p			o	
42	Cru	0.7	0.6	p/ccu		p			o	
43	Cru	0.6	0.5	p/ccu		p			o	
44	Vol	1.3	0.7	p/cvu		l			m	
45	Smyl	1.4	0.6	p/ccu		r			m	
46	Cru	0.6	0.6	i/ccu		p			o	
47	Ling	1.2	0.6	p/ccu		?			o	
48	Cru	0.9	0.8	p/ccu		p			o	
49	Cru	0.8	0.6	p/ccu		b			o	
50	Ling	0.7	0.4	p/cvu		?			o	
51	Ling	1.0	0.6	p/ccu		?			o	
52	Ling	1.0	0.7	p/cvu		?			o	
53	bur	3.2	0.3							
54	Cru	0.8	0.8	i/ccu		p			o	

DC-7b-2 (concluded)

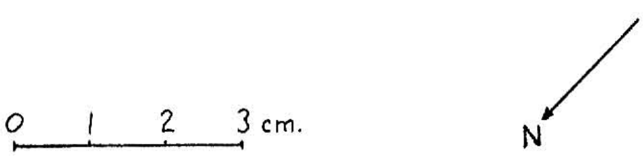
#	genus	long dem.	short dem.	orient	art	val	frag	epis	type pres	del
55	Cru	0.8	0.7	p/ccu		p			o	
56	Cru	0.7	0.6	p/ccu		p			o	
57	Cru	0.7	0.6	p/ccu		p			o	
58	brac	0.7	0.5	p/ccu		?	x		o	
59	Vol	1.9	0.8	p/cvu		r			m	
60	Cru	1.0	1.0	p/cvu		p			o	
61	Ling	1.3	0.7	p/ccu		?			o	
62	Vol	1.4	0.5	p/ccu	c	r			m	
63	Vol	1.2	0.5	p/cvu		r			m	

DC-7b-2



D = 1.541

E = 0.613

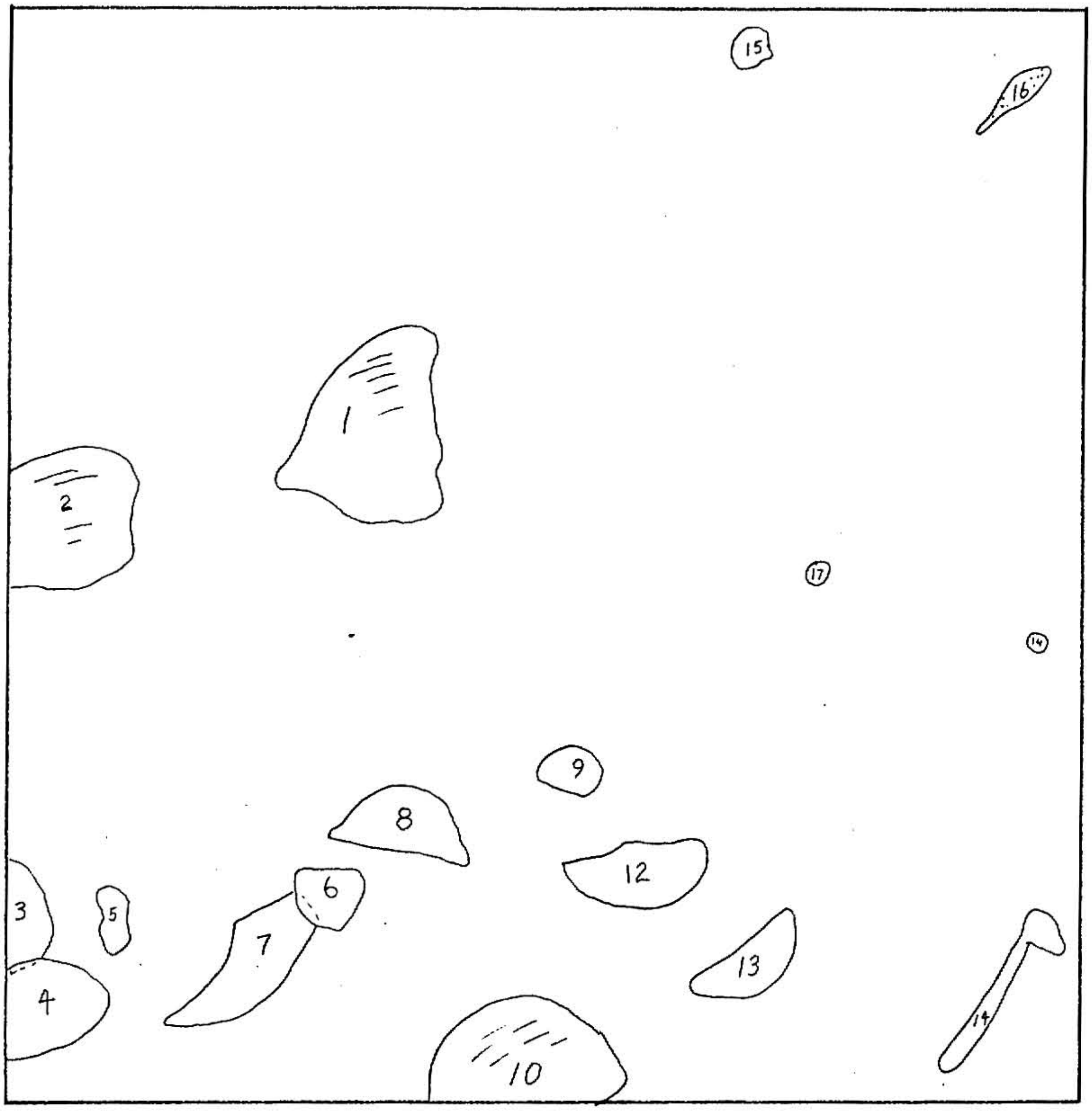


MICROFOSSIL RESIDUE — SAMPLE NUMBER DC - 7b - 2

Taxonomic Entities	Visual Percent Retained on Mesh Sieve			
	+10	+18	+32	+60
Foraminiferids				
Ammobaculites sp.				tr
Ammodiscus sp.				1
Textularids				
Fusulinids				
Ectoprocts				
Ramose 1				
Ramose 2				
Ramose 3				
Fenestrate 1				
Fenestrate 2				
Brachiopods				
Inarticulate				
Lingula sp.			1	15
Orbiculoidea sp.				
Petrocrania sp.				
Articulate				
Wellerella sp.				
Crurithyris sp.	40	5	2	
Derbyia sp.				
Meekella sp.				
Neochonetes sp.				
Lissochonetes sp.				
Reticulatia sp.				
Rhipidomella sp.				
Hustedia sp.				
Productid fragments				tr
Brachiopod fragments		15	47	5
Molluscs				
Bivalve fragments				
Myalinid fragments				
Gastropods				
Loxonematids				
Arthropods				
Smooth ostracodes				
Ornamented ostracodes				
Trilobite debris				
Barnacle plates				
Echinoderms				
Crinoid debris			tr	
Echinoid debris				
Ophiuroid? ossicles				
Holothurian sieve plates				
Fish debris				
Conodonts			tr	tr
Burrow fillings				
Worm tubes				
Matrix and unidentified fragments	60	80	50	79

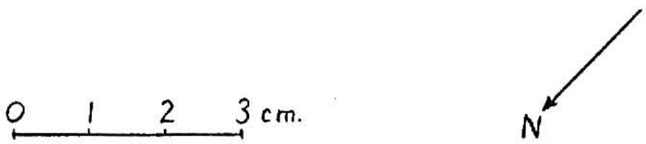
#	genus	long dem.	short dem.	orient	art	val	frag	epis	type pres	del
1	Lino	3.0	2.5	p/ccu	c	p			o	
2	Lino	4.3	2.5	p/ccu		p			o	
3	Lino	1.7	1.3	p/ccu		p	x		o	
4	Lino	1.3	1.5	p/cvu		p			o	
5	Cru	1.0	0.8	p/cvu		p	x		o	
6	Apec	0.8	0.7	p/cvu		?	x		m	
7	prod	3.4	2.2	p/cvu		b			o	
8	Nech	2.0	1.7	p/cvu		p			o	
9	Ret	0.7	0.6	p/cvu		p	x		o	
10	Lino	2.7	1.5	i/cvu		p			o	
11	crin	3.2	0.2	p/					o	
12	prod	2.8	2.0	p/cvu		b	x		o	
13	prod	2.3	2.0	p/cvu		p	x		o	
14	Cru	0.3	0.4	p/ccu		p	x		o	
15	Cru	0.7	0.7	p/cvu		p			o	
16	bur	0.2	1.9	p/					cal	
17	Cru	0.5	0.5	p/cvu		p			o	

DC-7d-1



D = 1.910

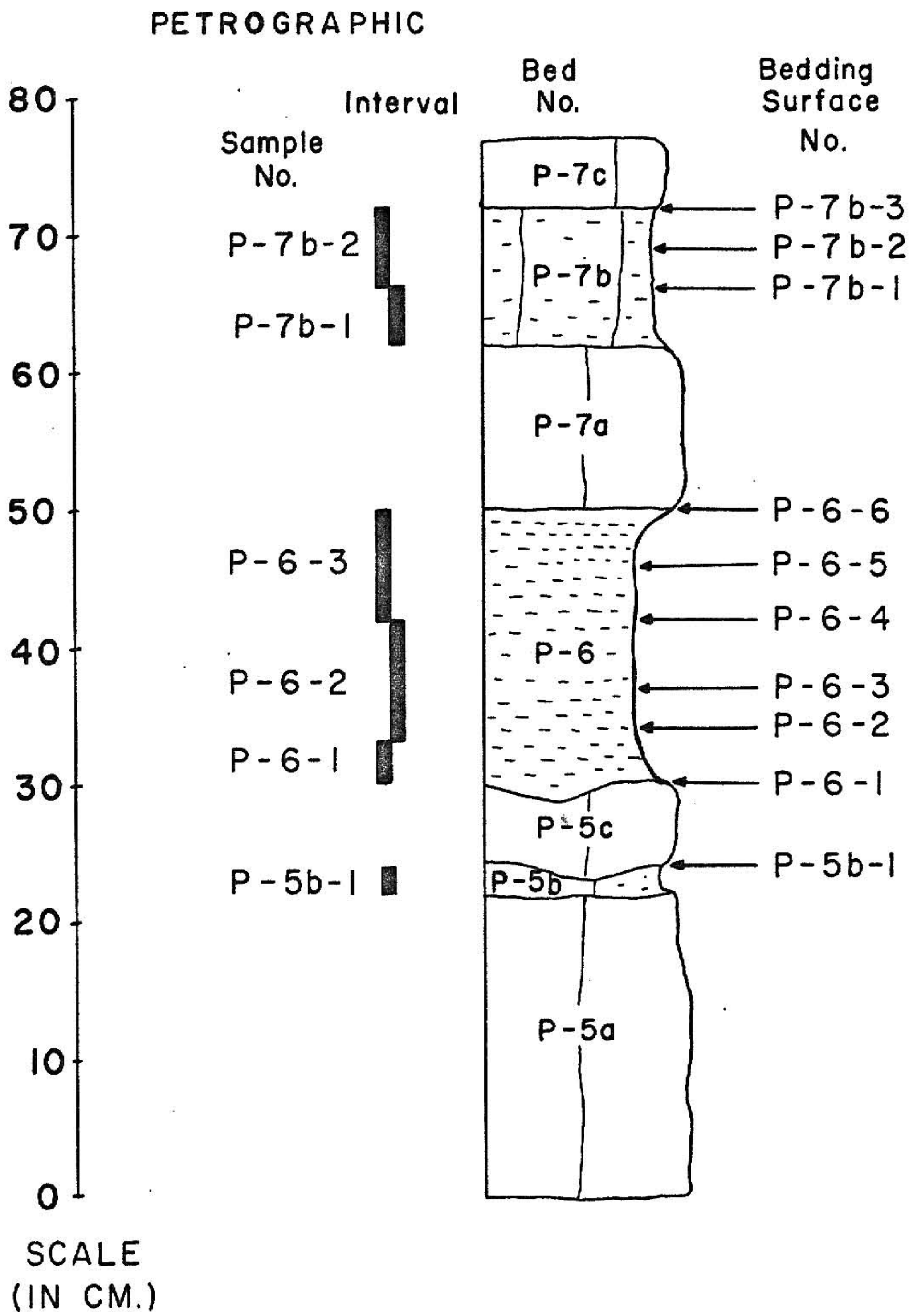
E = 0.981



MICROFOSSIL RESIDUE SAMPLE NUMBER DC - 7d - 1

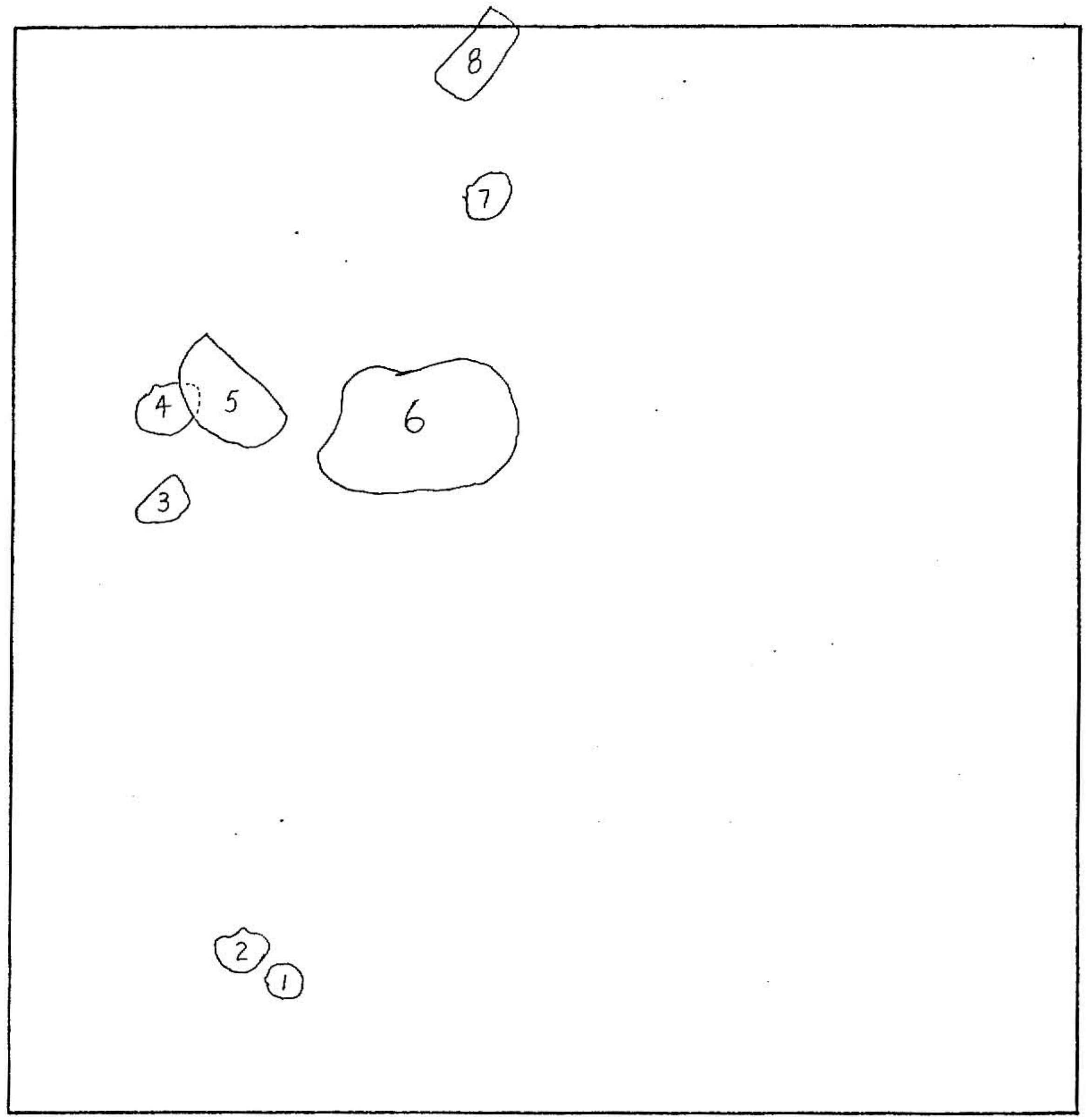
Taxonomic Entities	Visual Percent Retained on Mesh Sieve			
	+10	+18	+32	+60
Foraminiferids				
Ammobaculites sp.				tr
Ammodiscus sp.				1
Textularids				
Fusulinids				
Ectoprocts				
Ramose 1				
Ramose 2				
Ramose 3				
Fenestrate 1				
Fenestrate 2				
Brachiopods				
Inarticulate				
Lingula sp.				
Orbiculoidea sp.				
Petrocrania sp.				
Articulate				
Wellerella sp.				
Crurithyris sp.	25	50	5	1
Derbyia sp.				
Meekella sp.	2			
Neochonetes sp.				
Lissochonetes sp.				
Reticulatia sp.				
Rhipidomella sp.				
Hustedia sp.				
Productid fragments	20	15	30	25
Brachiopod fragments		10	40	30
Molluscs				
Bivalve fragments				
Myalinid fragments				
Gastropods				
Loxonematids				
Arthropods				
Smooth ostracodes				
Ornamented ostracodes				
Trilobite debris				
Barnacle plates				
Echinoderms				
Crinoid debris	3		1	1
Echinoid debris		2	1	
Ophiuroid? ossicles				tr
Holothurian sieve plates				
Fish debris			tr	
Conodonts				tr
Burrow fillings				
Worm tubes				tr
Matrix and unidentified fragments	50	23	23	42

PAXICO (P) SECTION



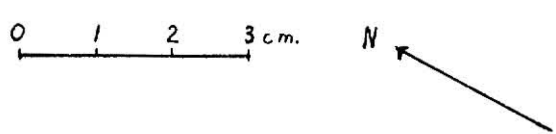
#	genus	long dem.	short dem.	orient	art	val	frag	epis	type pres	del
1	Nech	2.1	1.1	p/ccu	c	b			o	
2	brac	0.4	0.2	i/			x		o	
3	Cru	0.9	0.8	i/	c	p			o	
4	Nech	0.7	1.2	i/		p	x		o	
5	Nech	1.4	0.4	i/		p	x		o	
6	r III	4.7	1.5						o	
7	Nech	0.9	0.5	p/cvu		b			o	
8	Nech	1.1	0.5	p/cvu		p			o	
9	Nech	2.1	1.1	p/cvu		p	x		o	
10	Nech	2.1	1.1	i/cvu		p			o	
11	Cru	0.7	0.6	i/cvu		p			o	
12	Derb	1.1	0.9	i/cvu		b	x		o	
13	Ret	6.2	4.8	p/cvu		b			o	

P-5b-1



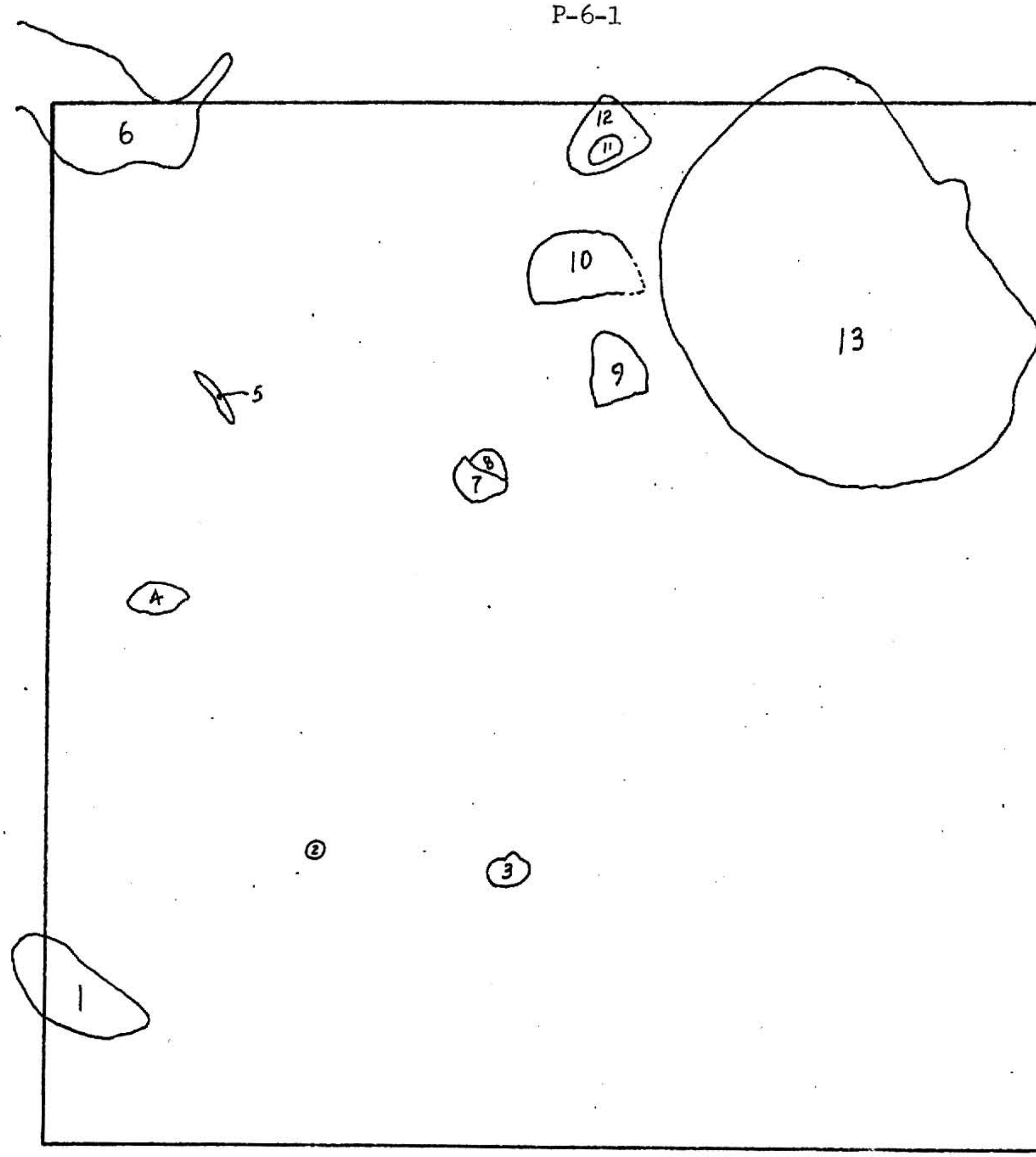
D = 2.003

E = 1.056



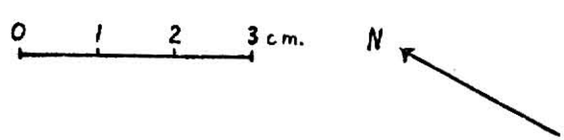
#	genus	long dem.	short dem.	orient	art val	frag	epis	type pres	del
1	Cru	0.6	0.5	p/cvu	p			o	
2	Cru	0.7	0.6	p/cvu	p			o	
3	Ret	0.9	0.6	i/	p	x		o	
4	Cru	1.0	1.0	p/cvu	p			o	
5	Nech	2.0	1.0	p/ccu	p			o	
6	Hyst	1.8	1.4	p/cvu	p			o	x
7	Cru	0.9	0.8	p/cvu	p			o	
8	crin	1.2	0.7	p/				o	

P-6-1



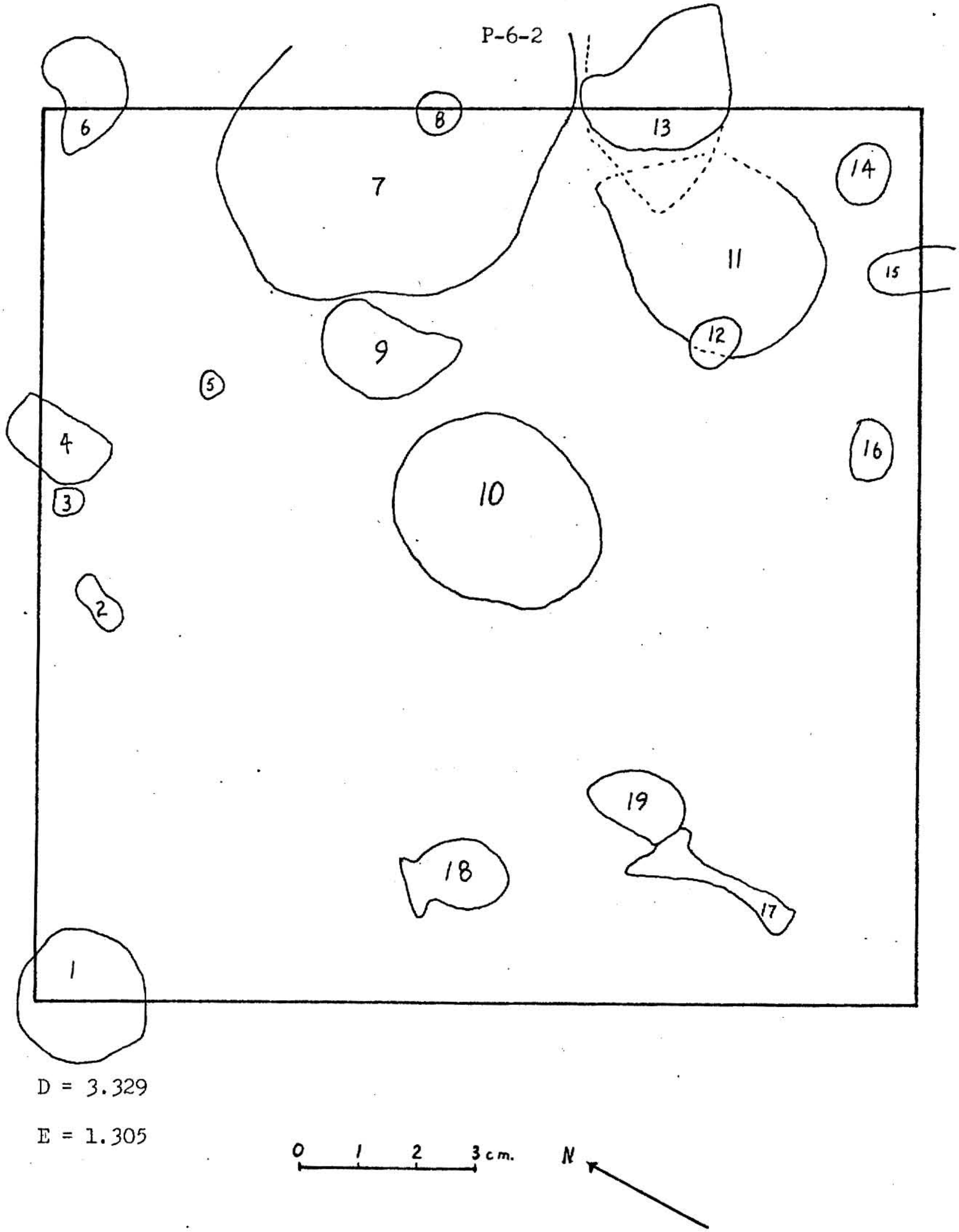
D = 1.874

E = 0.955



#	genus	long dem.	short dem.	orient	art	val	frag	epis	type pres	del
1	Rit	2.6	2.3	p/cvu		p			o	x
2	brac	1.0	0.4	p/			x		o	
3	Cru	0.6	0.4	p/cvu		p			o	
4	prod	1.7	1.0	p/ccu		p	x		o	
5	brac	0.3	0.2	p/			x		o	
6	Derb	1.8	1.4	p/ccu		b			o	
7	Myl	5.3	4.2	p/cvu		r		(8)	o	
8	Pet	0.7	0.6	p/cvu		p		(7)	o	
9	Rit	1.9	1.5	p/cvu		p	x		o&m	
10	Rit	3.8	3.6	p/cvu		p	x	bored	o&m	
11	Myl	3.8	3.2	p/cvu		r		(12)	o	
12	r I	0.8	0.5					(11)	o	
13	Nesp	4.6	2.8	p/cvu		b			o	
14	brac	0.4	0.3	p/cvu		b	x		o	
15	Ret	4.8	0.4	p/cvu		p	x		o	
16	Pet	0.6	0.5	p/cvu		p			o	
17	r II	3.2	0.2						o	
18	Apec	1.6	1.5	p/ccu					m&o	
19	Nech	2.1	1.0	i/		b			o	

P-6-2



D = 3.329

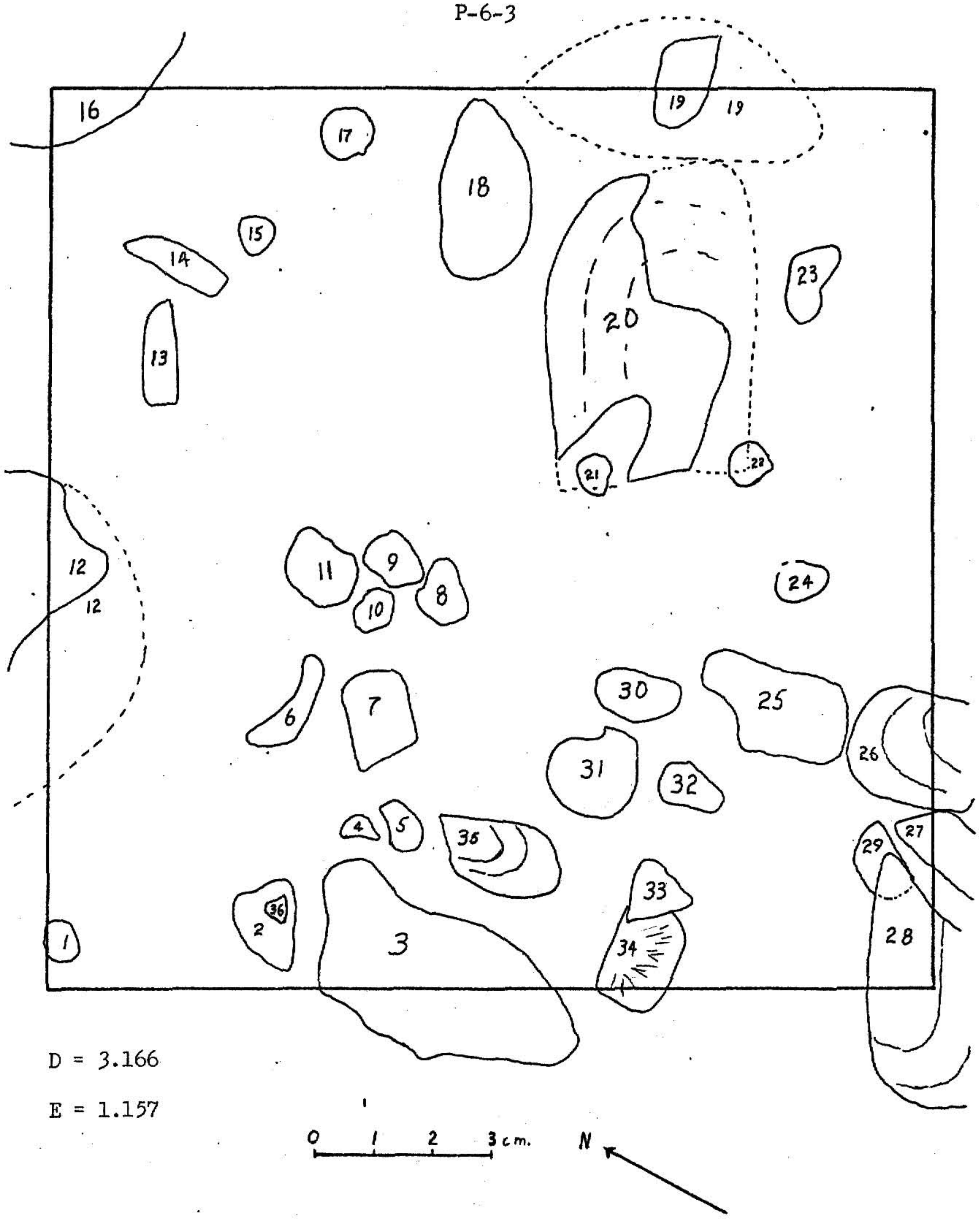
E = 1.305

MICROFOSSIL RESIDUE SAMPLE NUMBER P - 6 - 2

Taxonomic Entities	Visual Percent Retained on Mesh Sieve			
	+10	+18	+32	+60
Foraminiferids				
Ammobaculites sp.				
Ammodiscus sp.				
Textularids				
Fusulinids				
Ectoprocts				
Ramose 1	2	1		
Ramose 2		tr		
Ramose 3				
Fenestrate 1	2			
Fenestrate 2				
Brachiopods				
Inarticulate				
Lingula sp.				tr
Orbiculoidea sp.				
Petrocrania sp.				
Articulate				
Wellerella sp.				
Crurithyris sp.	23	10	4	1
Derbyia sp.		1		
Meekella sp.				
Neochonetes sp.	25			
Lissochonetes sp.				
Reticulatia sp.				
Rhipidomella sp.				
Hustedia sp.				
Productid fragments		10	7	30
Brachiopod fragments		40	20	20
Molluscs				
Bivalve fragments	6		1	
Myalinid fragments				
Gastropods				
Loxonematids				
Arthropods				
Smooth ostracodes			tr	
Ornamented ostracodes				
Trilobite debris				
Barnacle plates				
Echinoderms				
Crinoid debris			3	3
Echinoid debris	2	tr		tr
Ophiuroid? ossicles			tr	
Holothurian sieve plates				
Fish debris			tr	tr
Conodonts				
Burrow fillings				
Worm tubes				
Matrix and unidentified fragments	40	38	64	66

#	genus	long dem.	short dem.	orient	art	val	frag	epis	type pres	del
1	brac	0.7	0.3	i/			x		o	
2	f II	1.4	0.8	p/zeu			x		o	
3	brac	6.6	2.2	p/cvu			x		o	
4	uBv	0.7	0.4	p/cvu		r	x		o	
5	Pet	0.8	0.8	p/cvu		p			o	
6	Ret	2.2	0.9	i/		p	x		o	
7	f I	1.2	1.2	i/					o	
8	Pet	0.6	0.6	p/cvu		p			o	
9	f II	0.8	0.6	p/zeu					o	
10	Cru	0.7	0.7	p/cvu	c	p			o	
11	Apec	1.8	1.8	p/ccu		?	x		m	
12	Nesp	6.1	3.2	p/cvu		p			o	
13	uBv	1.8	0.7	i/			x		o	
14	r III	2.1	0.8	i/					o	
15	Pet	0.7	0.5	p/cvu		p			o	
16	Myl	5.6	4.5	p/cvu		r			o	
17	Apec	1.1	1.0	p/cvu		?			m&o	
18	Myl	3.0	1.9	i/cvu		l	x		o	
19	Nesp	5.7	2.8	p/cvu		b			o	
20	Myl	5.3	3.3	p/cvu		r			o	
21	Pet	0.6	0.6	p/cvu		p			o	
22	Cru	0.7	0.7	p/ccu		p			o	
23	f II	1.5	1.2	i/zed					o	
24	Pet	0.9	0.8	p/cvu		p			o	
25	Myl	2.9	1.5	p/			x		o	
26	Myl	2.4	1.8	p/ccu		r			m&o	
27	r III	3.3	1.4	p/					o	
28	Myl	4.2	2.8	P/cvu		r	x		m&o	
29	Nech	2.1	0.9	i/ccu		p			o	
30	Canc?	1.8	0.9	p/cvu		?	x		o	
31	Apec	1.6	1.5	p/ccu		r			m	
32	Pet	1.1	0.8	i/ccu				r I	o	
33	Nesp	1.3	1.2	p/ccu		?	x		o	
34	Apec	1.6	1.4	p/ccu		?			m	
35	Myl	1.9	1.1	p/ccu		r			m&o	
36	brac	0.4	0.3	p/cvu		?			o	

P-6-3



D = 3.166

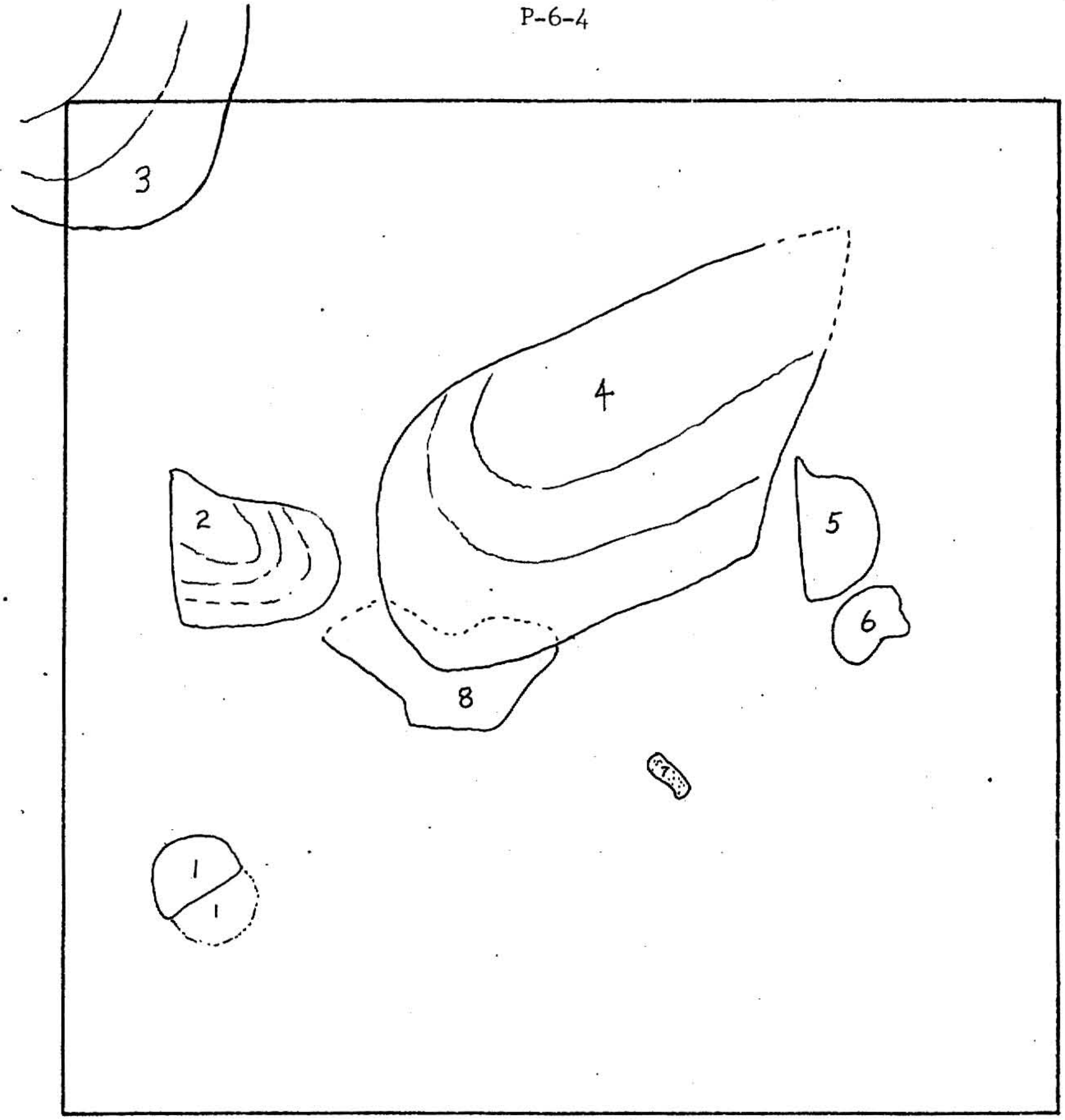
E = 1.157

MICROFOSSIL RESIDUE SAMPLE NUMBER P - 6 - 3

Taxonomic Entities	Visual Percent Retained on Mesh Sieve			
	+10	+18	+32	+60
Foraminiferids				
Ammobaculites sp.				
Ammodiscus sp.				
Textularids				
Fusulinids				
Ectoprocts				
Ramose 1	3	2		
Ramose 2	2			
Ramose 3	20			
Fenestrate 1		2	2	
Fenestrate 2	7	3	5	
Brachiopods				
Inarticulate				
Lingula sp.				
Orbiculoidea sp.				
Petrocrania sp.	5	tr		
Articulate				
Wellerella sp.				
Crurithyris sp.	2	3	tr	
Derbyia sp.	12	tr	tr	
Meekella sp.				
Neochonetes sp.	3			
Lissochonetes sp.				
Reticulatia sp.				
Rhipidomella sp.				
Hustedia sp.				
Productid fragments	20	3	5	20
Brachiopod fragments	10	40	30	20
Molluscs				
Bivalve fragments	15	7	5	
Myalinid fragments				
Gastropods				
Loxonematids				
Arthropods				
Smooth ostracodes			tr	2
Ornamented ostracodes				tr
Trilobite debris		tr	tr	
Barnacle plates				
Echinoderms				
Crinoid debris			2	3
Echinoid debris	1	2	tr	
Ophiuroid? ossicles				
Holothurian sieve plates				
Fish debris				
Conodonts				
Burrow fillings				
Worm tubes				
Matrix and unidentified fragments		38	51	55

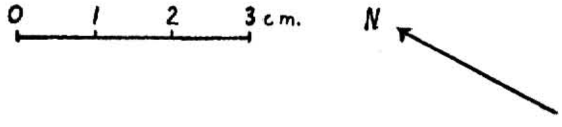
#	genus	long dem.	short dem.	orient	art	val	frag	epis	type pres	del
1	Derb	1.6	1.5	p/cvu		p	x		o	
2	Myl	3.4	2.5	p/ccu		r	x		o	
3	Myl	5.0	3.7	p/ccu		r			o	
4	Myl	6.8	4.5	p/cvu		r			o	
5	Nech	2.7	1.3	i/cvu		p			o	
6	uBv	1.3	1.0	p/		?	x		o	
7	bur	1.0	0.2	i/					lim	
8	r III	3.6	2.7	i/					o	

P-6-4



D = 1.797

E = 1.126

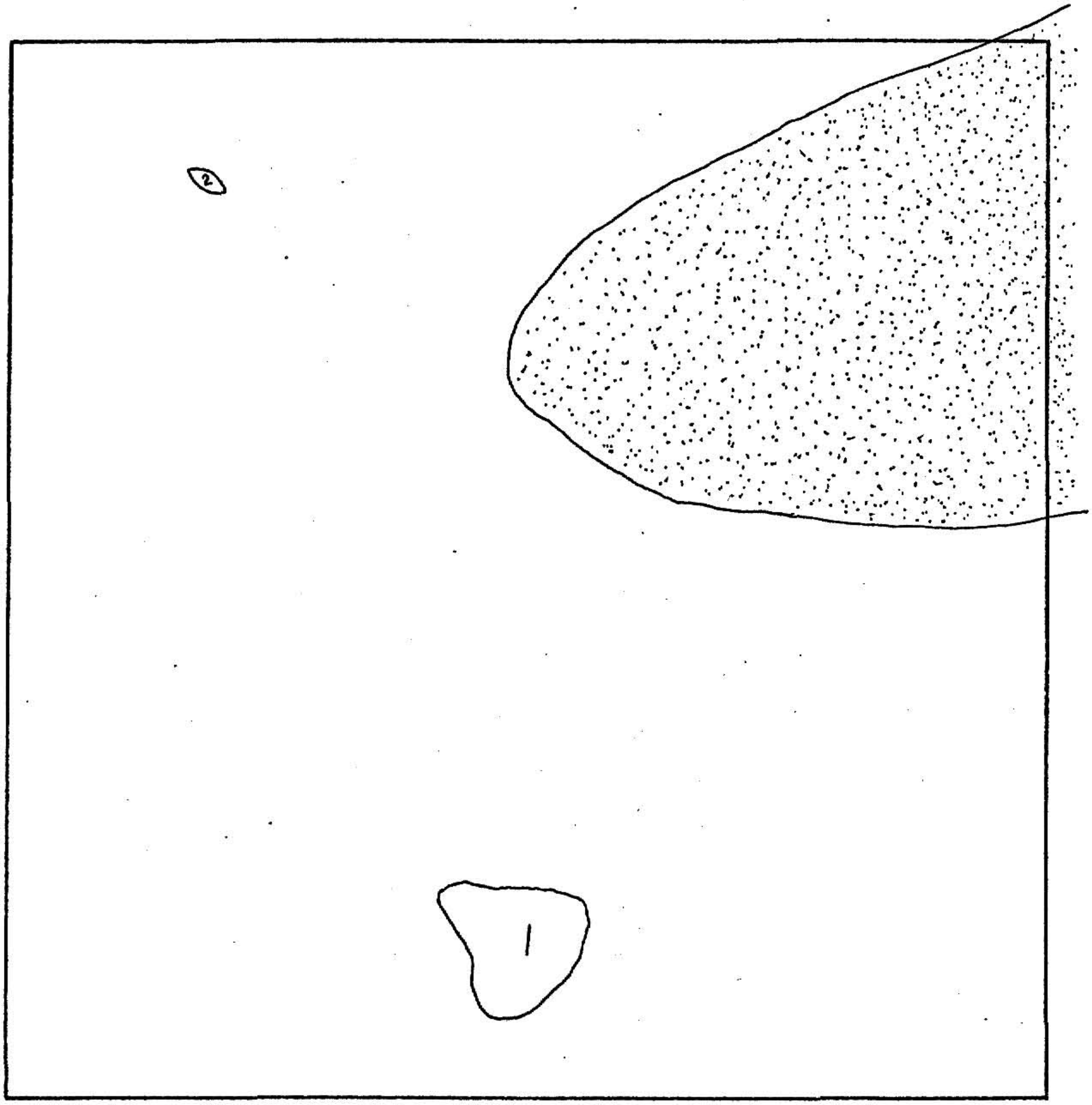


MICROFOSSIL RESIDUE — SAMPLE NUMBER P - 6 - 4

Taxonomic Entities	Visual Percent Retained on Mesh Sieve			
	+10	+18	+32	+60
Foraminiferids				
Ammobaculites sp.				
Ammodiscus sp.				
Textularids				
Fusulinids				
Ectoprocts				
Ramose 1	15			
Ramose 2	2	1		tr
Ramose 3	15	3		
Fenestrate 1	3	1	5	
Fenestrate 2	5	3	2	
Brachiopods				
Inarticulate				
Lingula sp.				
Orbiculoidea sp.				
Petrocrania sp.	10	2		
Articulate				
Wellerella sp.				
Crurithyris sp.	2	5	5	
Derbyia sp.	5	1		
Meekella sp.				
Neochonetes sp.		1		
Lissochonetes sp.				
Reticulatia sp.				
Rhipidomella sp.				
Hustedia sp.	3	1		
Productid fragments	15	5	10	10
Brachiopod fragments		50	30	20
Molluscs				
Bivalve fragments	20	3	2	1
Myalinid fragments				
Gastropods				
Loxonematids				
Arthropods				
Smooth ostracodes			tr	1
Ornamented ostracodes				tr
Trilobite debris		tr		
Barnacle plates				
Echinoderms				
Crinoid debris	5		1	1
Echinoid debris		1	tr	tr
Ophiuroid? ossicles				
Holothurian sieve plates				tr
Fish debris			tr	
Conodonts				
Burrow fillings				
Worm tubes				
Matrix and unidentified fragments		23	45	66

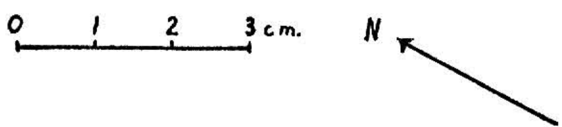
#	genus	long dem.	short dem.	orient	art	val	frag	epis	type pres	del
1	f II	2.1	1.6	i/zed			x		o	
2	fus	0.5	0.2	p/					o	

P-6-5



D = 1.003

E = 1.196

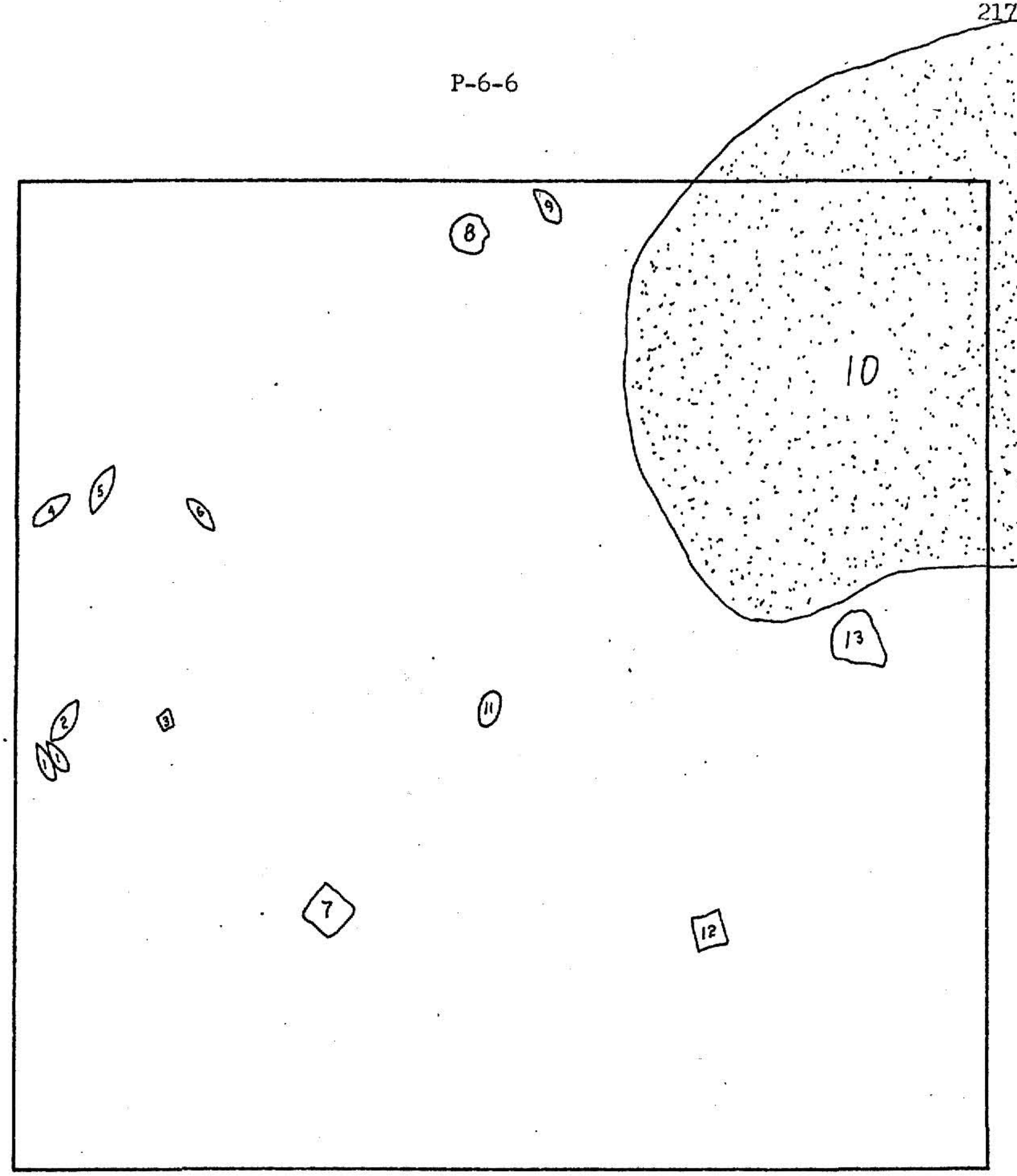


MICROFOSSIL RESIDUE SAMPLE NUMBER P - 6 - 5

Taxonomic Entities	Visual Percent Retained on Mesh Sieve			
	+10	+18	+32	+60
Foraminiferids				
Ammobaculites sp.				
Ammodiscus sp.				tr
Textularids				
Fusulinids				
Ectoprocts				
Ramose 1				
Ramose 2				
Ramose 3				
Fenestrate 1	15	15	1	tr
Fenestrate 2		2	1	tr
Brachiopods				
Inarticulate				
Lingula sp.				
Orbiculoidea sp.				
Petrocrania sp.	30	2		
Articulate				
Wellerella sp.				
Crurithyris sp.	15	15	10	
Derbyia sp.				
Meekella sp.				
Neochonetes sp.	15		tr	
Lissochonetes sp.				
Reticulatia sp.				
Rhipidomella sp.				
Hustedia sp.				
Productid fragments	15	10	15	5
Brachiopod fragments		20	30	15
Molluscs				
Bivalve fragments				
Myalinid fragments				
Gastropods				
Loxonematids				
Arthropods				
Smooth ostracodes			tr	1
Ornamented ostracodes				tr
Trilobite debris			tr	
Barnacle plates				
Echinoderms				
Crinoid debris		1	2	tr
Echinoid debris		tr	1	tr
Ophiuroid? ossicles				
Holothurian sieve plates				
Fish debris				
Conodonts				
Burrow fillings				
Worm tubes				
Matrix and unidentified fragments	10	20	40	78

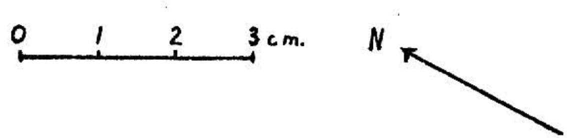
#	genus	long dem.	short dem.	orient	art	val	frag	epis	type pres	del
1	fus	0.7	0.2	i/					o	
2	fus	0.6	0.2	p/					o	
3	fus	0.3	0.2	i/			x		o	
4	fus	0.7	0.2	i/					o	
5	fus	0.8	0.2	i/					o	
6	fus	0.6	0.2	p/					o	
7	crin	0.6	0.5	p/					o	
8	crin	0.6	0.4	i/					o	
9	fus	0.5	0.2	p/					o	
10	bur	18.0	7.0	p/					cal	
11	brac	0.3	0.3	p/			x		o	
12	f pel	0.7	0.5						cal	
13	Lino	0.8	0.7	p/cvu		p	x		o	

P-6-6



D = 0.923

E = 0.743

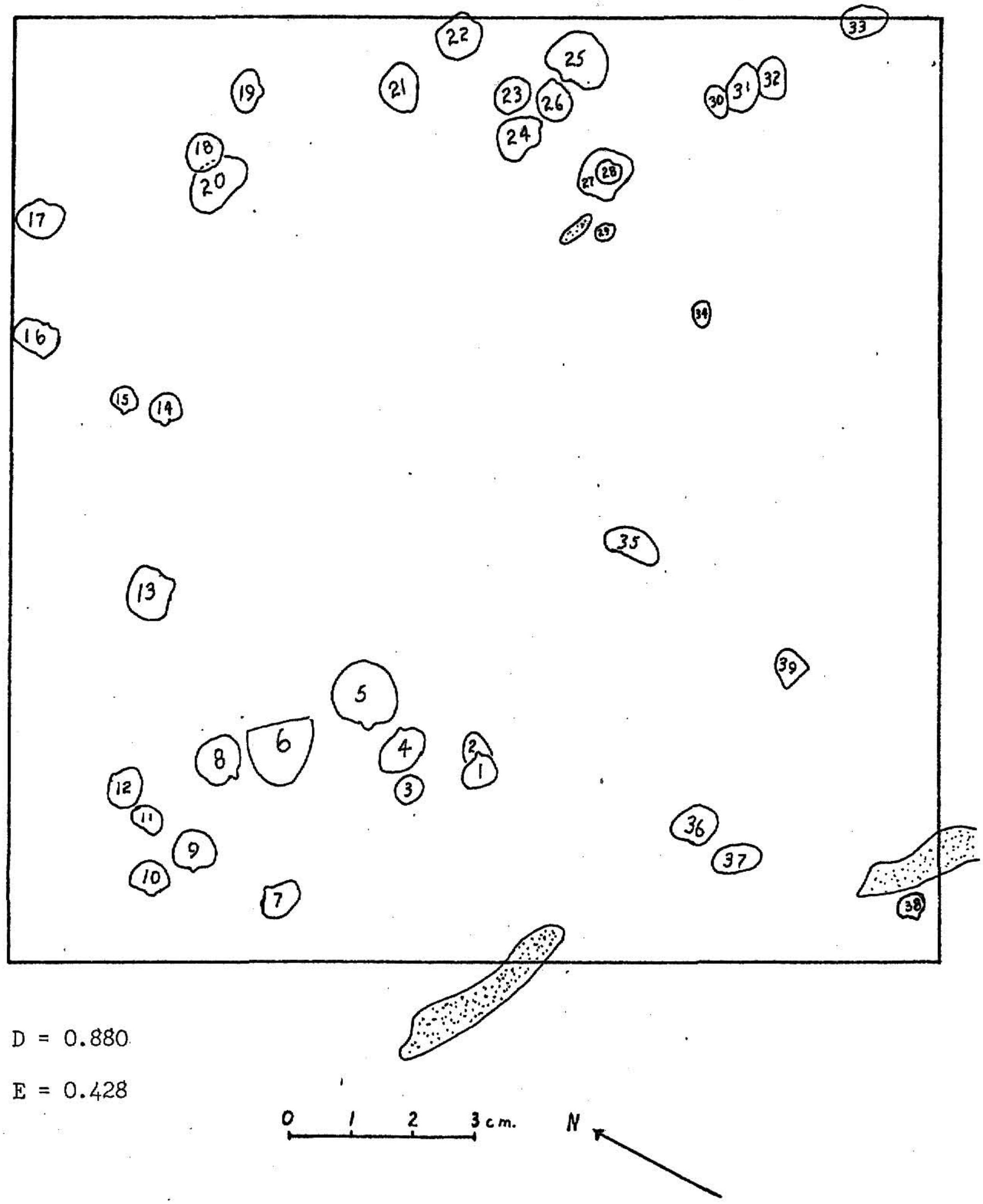


MICROFOSSIL RESIDUE SAMPLE NUMBER P - 6 - 6

Taxonomic Entities	Visual Percent Retained on Mesh Sieve			
	+10	+18	+32	+60
Foraminiferids				
Ammobaculites sp.				
Ammodiscus sp.				
Textularids				
Fusulinids	4	1	tr	tr
Ectoprocts				
Ramose 1				
Ramose 2	2	1		
Ramose 3				
Fenestrate 1				
Fenestrate 2			2	tr
Brachiopods				
Inarticulate				
Lingula sp.				
Orbiculoidea sp.				
Petrocrania sp.				
Articulate				
Wellerella sp.				
Crurithyris sp.	7	1		tr
Derbyia sp.				
Meekella sp.				
Neochonetes sp.		tr	tr	
Lissochonetes sp.				
Reticulatia sp.				
Rhipidomella sp.		tr		
Hustedia sp.	4	tr	tr	
Productid fragments		tr	5	5
Brachiopod fragments			10	10
Molluscs				
Bivalve fragments				
Myalinid fragments				
Gastropods				
Loxonematids				
Arthropods				
Smooth ostracodes			2	tr
Ornamented ostracodes				tr
Trilobite debris			tr	
Barnacle plates				
Echinoderms				
Crinoid debris	3	1	1	tr
Echinoid debris				tr
Ophiuroid? ossicles				
Holothurian sieve plates				
Fish debris				
Conodonts				
Burrow fillings				
Worm tubes				
Matrix and unidentified fragments	80	95	80	84

#	genus	long dem.	short dem.	orient	art	val	frag	epis	type pres	del
1	Cru	0.8	0.7	p/ccu		b			o	
2	Cru	0.9	0.7	p/cvu		p			o	
3	Cru	0.7	0.6	p/cvu		p			o	
4	Cru	0.8	0.6	p/cvu		b			o	
5	Cru	1.2	1.0	p/cvu	c	p			o	
6	uBv	1.4	0.6	p/		?	x		o&m	
7	Cru	0.8	0.7	p/cvu		p			o	
8	Cru	0.7	0.6	p/cvu	c	p			o	
9	Cru	0.8	0.7	p/ccu		p			o	
10	Cru	0.4	0.3	p/ccu		p			o	
11	Cru	0.6	0.6	p/cvu		b	x		o	
12	Cru	0.8	0.6	p/cvu		p	x		o	
13	Cru	1.0	0.7	p/cvu		p			o	
14	Cru	0.6	0.6	p/cvu		p			o	
15	Rhip	0.5	0.4	p/cvu		p			o	
16	Cru	0.6	0.5	p/cvu		p			o	
17	Cru	0.6	0.6	p/cvu		p			o	
18	Cru	0.5	0.4	p/cvu		p	x		o	
19	Cru	0.7	0.6	p/cvu		p			o	
20	Cru	1.1	0.8	p/cvu		b			o	
21	Cru	0.8	0.6	p/ccu		p			o	
22	Cru	0.8	0.7	p/ccu		p			o	
23	Cru	0.6	0.4	p/ccu		p			m	
24	Cru	1.0	0.8	p/ccu		p			o	
25	Cru	1.0	0.7	p/cvu		b			o	
26	brac	0.7	0.6	p/ccu		?	x		o	
27	Cru	0.6	0.7	p/ccu		p			o	
28	Cru	0.5	0.4	p/cvu		p			o	
29	Ost	0.3	0.2	p/cvu		?			o	
30	Cru	0.7	0.5	i/cvu		b			o	
31	Cru	0.5	0.4	p/ccu		p			o	
32	Cru	0.8	0.6	p/ccu		p	x		o	
33	brac	0.7	0.4	i/cvu		?	x		o	
34	crin	0.3	0.2						o	
35	Cru	1.0	0.8	p/ccu		p			o	
36	Cru	0.7	0.5	p/cvu		b			o	
37	Vol	0.7	0.6	p/ccu		r	x		m	
38	Cru	0.9	0.7	p/cvu		p			o	
39	Cru	0.8	0.6	p/cvu		b			o	

P-7b-1



D = 0.880

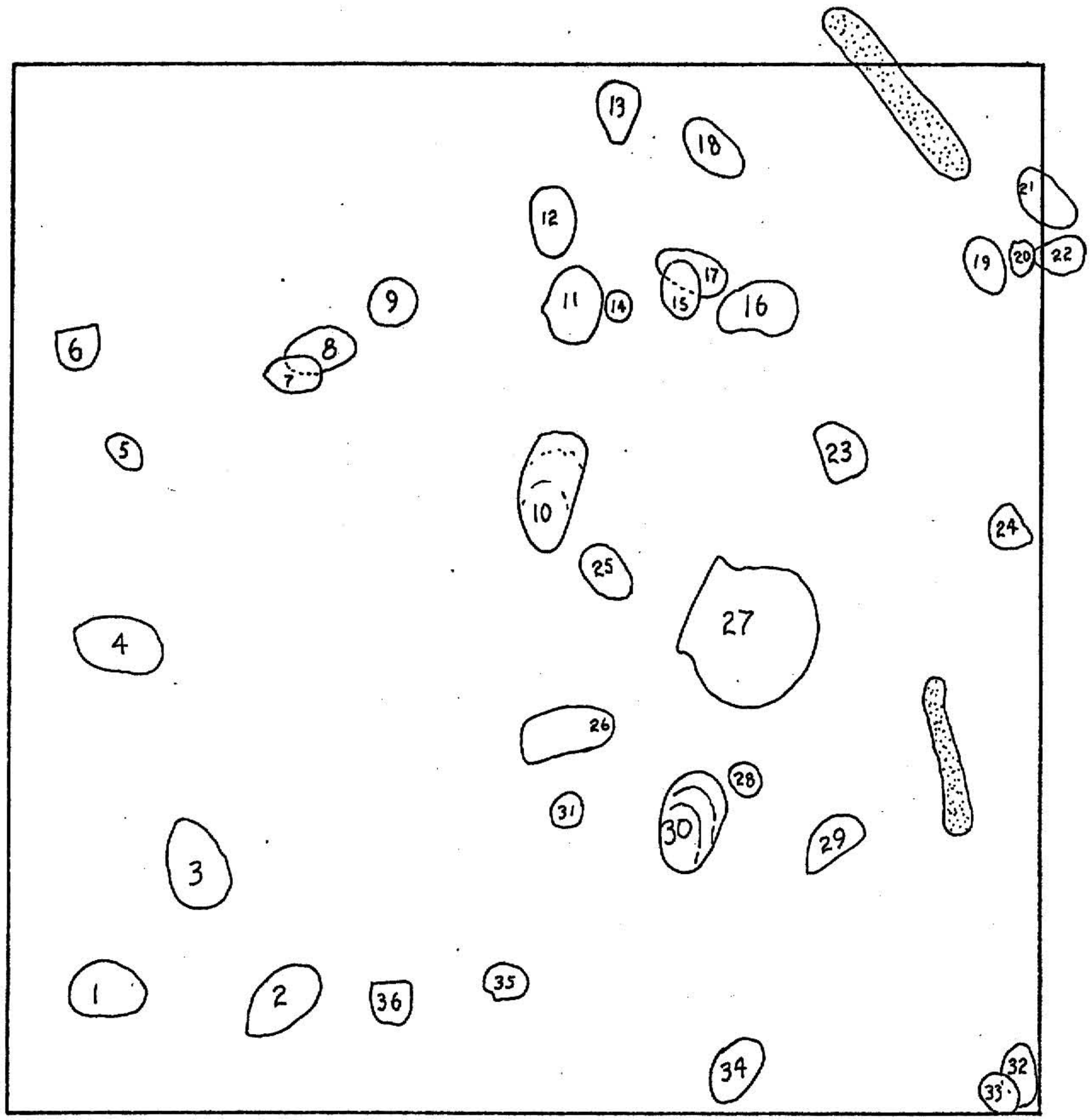
E = 0.428

MICROFOSSIL RESIDUE SAMPLE NUMBER P - 7b - 1

Taxonomic Entities	Visual Percent Retained on Mesh Sieve			
	+10	+18	+32	+60
Foraminiferids				
<u>Ammobaculites</u> sp.				
<u>Ammodiscus</u> sp.				1
Textularids				tr
Fusulinids				tr
Ectoprocts		tr		
Ramose 1				
Ramose 2				
Ramose 3				
Fenestrate 1				
Fenestrate 2				
Brachiopods				
Inarticulate				
<u>Lingula</u> sp.				
<u>Orbiculoidea</u> sp.			1	tr
<u>Petrocrania</u> sp.				
Articulate				
<u>Wellerella</u> sp.				
<u>Crurithyris</u> sp.				
<u>Derbyia</u> sp.	30	5	1	tr
<u>Meekella</u> sp.				
<u>Neochonetes</u> sp.		tr	tr	
<u>Lissochonetes</u> sp.				
<u>Reticulatia</u> sp.				
<u>Rhipidomella</u> sp.			tr	tr
<u>Hustedia</u> sp.				
Productid fragments		tr	1	5
Brachiopod fragments		10	15	20
Molluscs				
Bivalve fragments				
Myalinid fragments				
Gastropods				
Loxonematids				tr
Arthropods				
Smooth ostracodes				
Ornamented ostracodes				
Trilobite debris				
Barnacle plates				
Echinoderms				
Crinoid debris	1	2	tr	
Echinoid debris				
Ophiuroid? ossicles				
Holothurian sieve plates				
Fish debris			tr	
Conodonts				
Burrow fillings				
Worm tubes				
Matrix and unidentified fragments	69	83	82	73

#	genus	long dem.	short dem.	orient	art	val	frag	epis	type pres	del
1	Ling	1.2	0.8	p/ccu		?			o&m	
2	Ling	1.2	0.7	p/ccu		?			o	
3	Ling	1.5	0.9	p/cvu		?			o	
4	Ling	1.2	0.7	p/cvu		?			o	
5	Cru	0.6	0.5	p/ccu		b	x		o	
6	Ling	0.8	0.6	p/cvu		?	x		o	
7	Ling	0.9	0.5	p/ccu		?			m&o	
8	Ling	1.1	0.7	p/cvu		?	x		m&o	
9	Cru	0.6	0.5	p/ccu		p			o	
10	Vol	1.7	0.9	p/ccu		r			m&o	
11	Cru	0.8	0.6	p/ccu		b			o	
12	Ling	1.0	0.6	p/ccu		?	x		m	
13	Ling	1.0	0.6	p/cvu		?			o&m	
14	fi de	0.4	0.3	p/					o	
15	Cru	1.1	0.8	p/		b			o	
16	Ling	1.1	0.7	p/ccu		?			o	
17	Ling	1.0	0.6	p/cvu		?			o	
18	Ling	0.7	0.6	p/cvu		?	x		o	
19	Ling	0.8	0.5	p/ccu		?			o	
20	Cru	0.6	0.5	p/cvu		p			o	
21	Ling	1.2	0.8	p/cvu		?			m	
22	Ling	0.8	0.5	p/cvu		?			o	
23	Cru	0.7	0.5	p/cvu		b			o	
24	Cru	0.7	0.5	p/ccu		b			o	
25	Ling	0.9	0.6	p/cvu		?			o	
26	Vol	1.5	0.8	p/ccu		r			o&m	
27	Apec	2.2	2.0	p/ccu		r			o&m	
28	Ling	0.6	0.4	p/cvu		?	x		o	
29	Vol	1.1	0.6	p/ccu		?			m	
30	Vol	1.4	0.7	p/cvu		l			m	
31	Ling	0.5	0.5	p/cvu		?	x		o	
32	Cru	0.7	0.5	p/cvu		p			m	
33	Cru	0.6	0.5	p/cvu		p			o	
34	Ling	1.4	0.8	p/cvu		?			o	
35	Ling	0.7	0.4	i/cvu		?			o	
36	Ling	0.7	0.7	i/ccu		?	x		o	

P-7b-2



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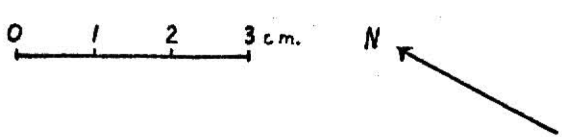
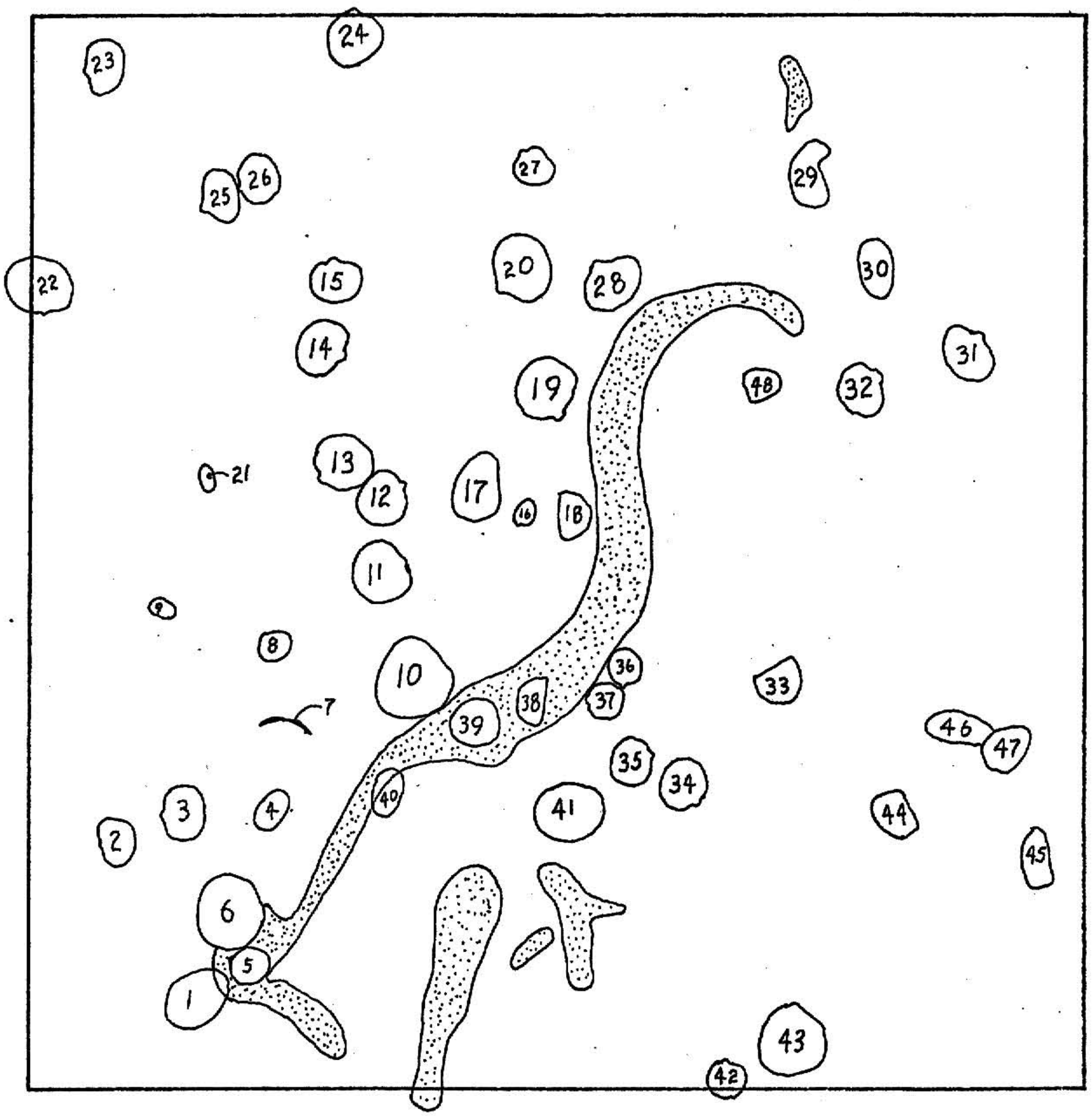


MICROFOSSIL RESIDUE SAMPLE NUMBER P - 7b - 2

Taxonomic Entities	Visual Percent Retained on Mesh Sieve			
	+10	+18	+32	+60
Foraminiferids				
Ammobaculites sp.				1
Ammodiscus sp.				1
Textularids				
Fusulinids				
Ectoprocts				
Ramose 1				
Ramose 2				
Ramose 3				
Fenestrate 1				
Fenestrate 2				
Brachiopods				
Inarticulate				
Lingula sp.			10	1
Orbiculoidea sp.				
Petrocrania sp.				
Articulate				
Wellerella sp.				
Crurithyris sp.	32	5	7	
Derbyia sp.				
Meekella sp.				
Neochonetes sp.		tr		
Lissochonetes sp.				
Reticulatia sp.				
Rhipidomella sp.				
Hustedia sp.				
Productid fragments	1	tr		tr
Brachiopod fragments		34	25	20
Molluscs				
Bivalve fragments				
Myalinid fragments				
Gastropods				
Loxonematids				
Arthropods				
Smooth ostracodes				
Ornamented ostracodes				
Trilobite debris				
Barnacle plates				
Echinoderms				
Crinoid debris			tr	tr
Echinoid debris				
Ophiuroid? ossicles				
Holothurian sieve plates				
Fish debris				
Conodonts				
Burrow fillings				
Worm tubes				
Matrix and unidentified fragments	67	60	58	68

#	genus	long dem.	short dem.	orient	art	val	frag	epis	type pres	del
1	Ling	1.3	0.8	i/cvu		?			m&o	
2	Cru	0.9	0.7	p/cvu		b			o	
3	Cru	1.0	0.8	p/ccu		p			o	
4	brac	0.5	0.3	p/		?	x		o	
5	Cru	0.6	0.6	p/ccu		p			o	
6	Orb	1.2	1.1	p/cvu		p			m&o	
7	Cru	0.9	0.8	p/cvu		p			o	
8	Cru	0.7	0.4	p/ccu.		?	x		o	
9	brac	0.3	0.2	p/			x		o	
10	Cru	1.2	0.9	p/cvu		p			o	
11	Cru	0.9	0.7	p/ccu		p			o	
12	Cru	0.9	0.7	p/ccu		p			o	
13	Cru	0.9	0.7	p/ccu		p			o	
14	Cru	1.0	0.8	p/cvu		p			o	
15	Cru	0.8	0.7	p/cvu		p			o	
16	Ling	0.3	0.3	p/cvu		?			o	
17	Cru	1.1	0.9	p/cvu		b			o	
18	Cru	0.8	0.6	p/cvu		b			o	
19	Cru	1.0	0.8	p/cvu		p			o	
20	Cru	1.0	0.8	p/ccu		p			o	
21	Cru	0.4	0.3	p/ccu		b	x		o	
22	Cru	0.8	0.8	p/ccu		p			o	
23	Ling	0.8	0.7	p/cvu		?	x		o	
24	Cru	0.9	0.8	p/cvu		p			o	
25	Cru	0.7	0.6	p/cvu		p			o	
26	Cru	0.7	0.7	p/cvu		p			o	
27	Cru	0.7	0.5	p/cvu		p	x		o	
28	Cru	0.9	0.7	p/ccu		b			o	
29	Cru	0.8	0.5	p/cvu		?	x		o	
30	Ling	0.8	0.4	p/cvu		?			m	
31	Cru	0.9	0.7	p/cvu		p			o	
32	Cru	0.9	0.8	p/cvu		p			o	
33	Cru	0.7	0.5	p/ccu		b			o	
34	Cru	0.9	0.7	p/cvu		b			o	
35	Cru	0.9	0.7	p/cvu		p			o	
36	Cru	1.0	0.8	p/cvu		p			o	
37	Cru	0.8	0.6	p/cvu		p			o	
38	Cru	1.1	0.8	p/cvu		b			o	
39	Cru	1.1	0.8	p/ccu		b			o	
40	Cru	0.6	0.4	p/ccu		b	x		o	
41	Cru	1.1	0.9	p/cvu		p			o	
42	Cru	1.0	0.8	p/cvu		p			o	
43	Cru	0.9	0.8	p/cvu		p			o	
44	Cru	0.9	0.7	p/cvu		b			o	
45	Ling	0.9	0.2	i/cvu		?	x		o	
46	Cru	0.8	0.6	p/ccu		b			o	
47	Cru	0.8	0.7	p/ccu		p			o	
48	Ling	0.4	0.3	i/		?	x		m&o	

P-7b-3



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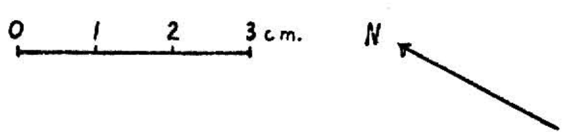


MICROFOSSIL RESIDUE — SAMPLE NUMBER P - 7b - 3

Taxonomic Entities	Visual Percent Retained on Mesh Sieve			
	+10	+18	+32	+60
Foraminiferids				
Ammobaculites sp.				1
Ammodiscus sp.				
Textularids				
Fusulinids				
Ectoprocts				
Ramose 1				
Ramose 2				
Ramose 3				
Fenestrate 1				tr
Fenestrate 2				
Brachiopods				
Inarticulate				
Lingula sp.			3	15
Orbiculoidea sp.				
Petrocrania sp.				
Articulate				
Wellerella sp.				
Crurithyris sp.	10	5	5	
Derbyia sp.				
Meekella sp.				
Neochonetes sp.				
Lissochonetes sp.				
Reticulatia sp.				
Rhipidomella sp.				
Hustedia sp.				
Productid fragments				
Brachiopod fragments		7	15	7
Molluscs				
Bivalve fragments				
Myalinid fragments				
Gastropods				
Loxonematids				
Arthropods				
Smooth ostracodes				tr
Ornamented ostracodes				
Trilobite debris				
Barnacle plates				
Echinoderms				
Crinoid debris				tr
Echinoid debris				
Ophiuroid? ossicles				
Holothurian sieve plates				
Fish debris				tr
Conodonts				
Burrow fillings				
Worm tubes				
Matrix and unidentified fragments	90	88	77	77

APPENDIX III

Grain Size Data

W-8-1

Class Interval in Ø Units	Class Wt.	Cumulative Wt.	Cumulative Percent Coarser
4.00	0.008	10.203	
4.00- 4.99	.015	10.195	0.08
5.00- 5.99	.495	10.180	0.23
6.00- 6.99	1.735	9.685	5.08
7.00- 7.99	1.620	7.950	22.08
8.00- 8.99	1.165	6.330	37.96
9.00- 9.99	.995	5.165	49.38
10.00-10.99	.710	4.170	59.13
11.00-11.99	.815	3.460	66.08
12.00-12.99		2.645	74.08
13.00-13.99			

W-8-2

Class Interval in Ø Units	Class Wt.	Cumulative Wt.	Cumulative Percent Coarser
4.00	0.018	14.718	
4.00- 4.99	.035	14.700	0.12
5.00- 5.99	.990	14.665	0.36
6.00- 6.99	3.000	13.675	7.09
7.00- 7.99	2.405	10.675	27.47
8.00- 8.99	1.430	8.270	43.81
9.00- 9.99	1.110	6.840	53.53
10.00-10.99	.855	5.730	61.07
11.00-11.99	1.175	4.875	66.80
12.00-12.99	1.305	3.700	74.86
13.00-13.99		2.395	83.73

W-8-3

Class Interval in Ø Units	Class Wt.	Cumulative Wt.	Cumulative Percent Coarser
4.00	0.021	13.471	
4.00- 4.99	0.135	13.450	0.16
5.00- 5.99	0.830	13.315	1.15
6.00- 6.99	3.220	12.485	7.32
7.00- 7.99	1.885	9.265	31.22
8.00- 8.99	1.220	7.380	45.22
9.00- 9.99	1.085	6.160	54.27
10.00-10.99	1.045	5.075	62.33
11.00-11.99		4.030	70.08
12.00-12.99			
13.00-13.99			

W-9b

Class Interval in Ø Units	Class Wt.	Cumulative Wt.	Cumulative Percent Coarser
< 4.00	0.016	12.106	
4.00- 4.99	.080	12.090	0.13
5.00- 5.99	.690	12.010	0.79
6.00- 6.99	1.780	11.320	6.49
7.00- 7.99	1.620	9.540	21.20
8.00- 8.99	1.120	7.920	34.58
9.00- 9.99	1.220	6.800	43.83
10.00-10.99	1.210	5.580	53.91
11.00-11.99		4.370	63.90
12.00-12.99			

L-8-1

Class Interval in Ø Units	Class Wt.	Cumulative Wt. in grams	Cumulative Percent Coarser
4.00	0.027	11.462	
4.00- 4.99	.160	11.435	0.24
5.00- 5.99	,500	11.275	1.63
6.00- 6.99	2.570	10.775	5.99
7.00- 7.99	1.415	8.205	28.42
8.00- 8.99	1.140	6.790	40.76
9.00- 9.99	.950	5.650	50.71
10.00-10.99	1.460	4.700	59.00
11.00-11.99		3.240	71.73
12.00-12.99			
13.00-13.99			

L-8-2

Class Interval in Ø Units	Class Wt.	Cumulative Wt.	Cumulative Percent Coarser
< 4.00	0.036	16.046	
4.00- 4.99	.155	16.010	0.24
5.00- 5.99	1.015	15.855	1.19
6.00- 6.99	3.310	14.840	7.14
7.00- 7.99	2.290	11.530	28.14
8.00- 8.99	1.405	9.240	42.42
9.00- 9.99	1.280	7.835	51.17
10.00-10.99	1.315	6.555	59.15
11.00-11.99		5.240	67.34
12.00-12.99			
13.00-13.99			

L-8-3

Class Interval in Ø Units	Class Wt.	Cumulative Wt.	Cumulative Percent Coarser
4.00	.006	10.386	
4.00- 4.99	.160	10.380	0.06
5.00- 5.99	.815	10.220	7.60
6.00- 6.99	2.275	9.405	9.44
7.00- 7.99	1.490	7.130	31.35
8.00- 8.99	.700	5.640	45.70
9.00- 9.99	.800	4.940	52.44
10.00-10.99	.950	4.140	60.14
11.00-11.99		3.190	69.29
12.00-12.99			
13.00-13.99			

L-10-1

Class Interval in Ø Units	Class Wt.	Cumulative Wt.	Cumulative Percent Coarser
$<$ 4.00	0.013	8.238	
4.00- 4.99	.340	8.225	0.16
5.00- 5.99	.520	7.885	4.29
6.00- 6.99	1.385	7.365	10.60
7.00- 7.99	.510	5.980	27.41
8.00- 8.99	.740	5.470	33.60
9.00- 9.99	.790	4.730	42.58
10.00-10.99	.620	3.940	52.17
11.00-11.99		3.320	59.70
12.00-12.99			
13.00-13.99			

L-10-2

Class Interval in Ø Units	Class Wt.	Cumulative Wt.	Cumulative Percent Coarser
< 4.00	0.017	16.102	
4.00- 4.99	.250	16.085	0.11
5.00- 5.99	.910	15.835	1.66
6.00- 6.99	2.210	14.925	7.31
7.00- 7.99	1.555	12.715	21.04
8.00- 8.99	1.505	11.160	30.69
9.00- 9.99	1.795	9.655	40.04
10.00-10.99	.765	7.860	51.19
11.00-11.99		7.095	55.94
12.00-12.99			

BR-3-1

Class Interval in Ø Units	Class Wt.	Cumulative Wt.	Cumulative Percent Coarser
< 4.00	0.044	14.089	
4.00- 4.99	0.090	14.045	0.31
5.00- 5.99	0.900	13.955	0.95
6.00- 6.99	2.015	13.055	7.34
7.00- 7.99	2.260	11.040	21.64
8.00- 8.99	1.515	8.780	37.68
9.00- 9.99	1.190	7.265	48.44
10.00-10.99	1.090	6.075	56.88
11.00-11.99	1.280	4.985	64.62
12.00-12.99		3.705	73.70

BR-3-2

Class Interval in Ø Units	Class Wt.	Cumulative Wt.	Cumulative Percent Coarser
< 4.00	0.014	13.259	
4.00- 4.99	.105	13.245	0.11
5.00- 5.99	.985	13.140	0.90
6.00- 6.99	1.955	12.155	8.33
7.00- 7.99	1.970	10.200	23.07
8.00- 8.99	1.300	8.230	37.93
9.00- 9.99	.805	6.930	47.73
10.00-10.99	1.775	6.125	53.80
11.00-11.99		4.350	67.19
12.00-12.99			

BR-4b

Class Interval in Ø Units	Class Wt.	Cumulative Wt.	Cumulative Percent Coarser
< 4.00	0.057	6.487	
4.00- 4.99	.110	6.430	0.88
5.00- 5.99	.395	6.320	2.58
6.00- 6.99	1.060	5.925	8.66
7.00- 7.99	.755	4.865	25.00
8.00- 8.99	.670	4.110	36.64
9.00- 9.99	.650	3.440	46.97
10.00-10.99	.605	2.790	56.99
11.00-11.99		2.185	66.32
12.00-12.99			

DC-6-1

Class Interval in Ø Units	Class Wt.	Cumulative Wt.	Cumulative Percent Coarser
4.00	0.052	19.452	
4.00- 4.99	.010	19.400	0.27
5.00- 5.99	.980	19.390	0.32
6.00- 6.99	3.315	18.410	5.36
7.00- 7.99	3.075	15.095	22.40
8.00- 8.99	2.150	12.020	38.21
9.00- 9.99	1.580	9.870	49.26
10.00-10.99	1.555	8.290	57.36
11.00-11.99		6.735	65.38
12.00-12.99			
13.00-13.99			

DC-6-2

Class Interval in Ø Units	Class Wt.	Cumulative Wt.	Cumulative Percent Coarser
< 4.00	0.022	9.337	
4.00- 4.99	.055	9.315	0.24
5.00- 5.99	.490	9.260	0.82
6.00- 6.99	1.595	8.770	6.07
7.00- 7.99	1.550	7.175	23.16
8.00- 8.99	.840	5.625	39.76
9.00- 9.99	.710	4.785	48.75
10.00-10.99	1.140	4.075	56.35
11.00-11.99		2.935	68.57
12.00-12.99			

DC-6-3

Class Interval in Ø Units	Class Wt.	Cumulative Wt.	Cumulative Percent Coarser
4.00	.036	8.976	
4.00- 4.99	.225	8.940	0.40
5.00- 5.99	.700	8.715	2.91
6.00- 6.99	1.705	8.015	10.71
7.00- 7.99	1.500	6.310	29.70
8.00- 8.99	.775	4.810	46.42
9.00- 9.99	.745	4.035	55.05
10.00-10.99	.630	3.290	63.35
11.00-11.99		2.660	70.37
12.00-12.99			
13.00-13.99			

DC-7b-1

Class Interval in Ø Units	Class Wt.	Cumulative Wt.	Cumulative Percent Coarser
< 4.00	0.021	11.761	
4.00- 4.99	.210	11.740	0.18
5.00- 5.99	.675	11.530	1.96
6.00- 6.99	1.620	10.855	7.70
7.00- 7.99	1.415	9.235	21.48
8.00- 8.99	1.425	7.820	33.51
9.00- 9.99	1.290	6.395	45.63
10.00-10.99	1.365	5.105	56.59
11.00-11.99		3.740	68.20
12.00-12.99			

DC-7d-1

Class Interval in Ø Units	Class Wt.	Cumulative Wt.	Cumulative Percent Coarser
4.00	0.164	8.374	
4.00- 4.99	.430	8.210	1.96
5.00- 5.99	.415	7.780	7.09
6.00- 6.99	.880	7.365	12.05
7.00- 7.99	1.025	6.485	22.56
8.00- 8.99	.845	5.460	34.80
9.00- 9.99	.710	4.615	44.89
10.00-10.99	.585	3.905	53.37
11.00-11.99		3.320	60.35
12.00-12.99			
13.00-13.99			

P-5b-1

Class Interval in Ø Units	Class Wt. in Grams	Cumulative Wt.	Cumulative Percent Coarser
4.00	0.055	8.100	
4.00- 4.99	.040	8.045	0.68
5.00- 5.99	.935	8.005	1.17
6.00- 6.99	1.565	7.070	12.72
7.00- 7.99	1.070	5.505	32.04
8.00- 8.99	.795	4.435	45.25
9.00- 9.99	.615	3.640	55.06
10.00-10.99	.580	3.025	62.65
11.00-11.99		2.445	69.81
12.00-12.99			

P-6-1

Class Interval in Ø Units	Class Wt.	Cumulative Wt.	Cumulative Percent Coarser
4.00	0.070	9.485	
4.00- 4.99	.120	9.415	0.74
5.00- 5.99	.610	9.295	2.00
6.00- 6.99	1.575	8.685	8.43
7.00- 7.99	1.345	7.110	25.04
8.00- 8.99	.965	5.765	39.22
9.00- 9.99	.520	4.800	49.39
10.00-10.99	1.500	4.280	54.88
11.00-11.99		2.780	70.69
12.00-12.99			
13.00-13.99			

P-6-2 First Trial

Class Interval in Ø Units	Class Wt.	Cumulative Wt.	Cumulative Percent Coarser
< 4.00	0.017	15.992	
4.00- 4.99	.075	15.975	0.11
5.00- 5.99	1.215	15.900	0.58
6.00- 6.99	3.275	14.685	8.17
7.00- 7.99	2.325	11.410	28.65
8.00- 8.99	1.490	9.085	43.19
9.00- 9.99	1.434	7.595	52.51
10.00-10.99	1.071	6.161	61.48
11.00-11.99	1.385	5.090	68.17
12.00-12.99	1.530	3.705	76.83
		2.175	86.40

P-6-2 Second Trial

Class Interval in Ø Units	Class Wt.	Cumulative Wt.	Cumulative Percent Coarser
< 4.00	0.027	14.997	
4.00- 4.99	.110	14.970	0.18
5.00- 5.99	1.090	14.860	0.91
6.00- 6.99	3.145	13.770	8.18
7.00- 7.99	2.260	10.625	29.15
8.00- 8.99	1.595	8.365	44.22
9.00- 9.99	1.260	6.770	54.86
10.00-10.99	.850	5.510	63.26
11.00-11.99	1.575	4.660	68.93
12.00-12.99	1.280	3.085	79.43
		1.805	87.96

P-6-3

Class Interval in Ø Units	Class Wt.	Cumulative Wt.	Cumulative Percent Coarser
< 4.00	0.016	12.496	
4.00- 4.99	.120	12.480	0.13
5.00- 5.99	.765	12.360	1.09
6.00- 6.99	2.850	11.595	7.21
7.00- 7.99	1.915	8.745	30.02
8.00- 8.99	1.195	6.830	45.34
9.00- 9.99	1.000	5.635	54.91
10.00-10.99	.810	4.635	62.91
11.00-11.99	.985	3.825	69.39
12.00-12.99	1.215	2.840	77.27
		1.625	87.00

P-7b-1

Class Interval in Ø Units	Class Wt.	Cumulative Wt.	Cumulative Percent Coarser
4.00	0.051	11.761	
4.00- 4.99	.205	11.710	0.43
5.00- 5.99	.335	11.505	2.18
6.00- 6.99	1.375	11.170	5.03
7.00- 7.99	1.685	9.795	16.72
8.00- 8.99	1.600	8.110	31.04
9.00- 9.99	1.220	6.510	44.65
10.00-10.99	1.220	5.290	55.02
11.00-11.99	1.245	4.070	65.31
12.00-12.99	1.320	2.825	75.98
13.00-13.99		1.505	87.20

P-7b-2

Class Interval in Ø Units	Class Wt.	Cumulative Wt.	Cumulative Percent Coarser
< 4.00	0.003	8.193	
4.00- 4.99	.195	8.190	0.04
5.00- 5.99	.305	7.995	2.42
6.00- 6.99	1.040	7.690	6.14
7.00- 7.99	1.460	6.650	18.83
8.00- 8.99	1.370	5.190	36.65
9.00- 9.99	1.065	3.820	53.38
10.00-10.99	.915	2.755	66.37
11.00-11.99		1.840	77.54
12.00-12.99			

W-8-1 H_2O_2 Treated

Class Interval in Ø Units	Class Wt.	Cumulative Wt.	Cumulative Percent Coarser
< 4.00	.004	11.459	
4.00- 4.99	.110	11.455	.04
5.00- 5.99	.365	11.345	1.00
6.00- 6.99	1.815	10.980	4.18
7.00- 7.99	2.025	9.165	20.02
8.00- 8.99	1.185	7.140	37.69
9.00- 9.99	.985	5.955	48.03
10.00-10.99	.660	4.970	56.63
11.00-11.99	.980	4.310	62.39
12.00-12.99		3.330	70.94

L-8-1 H_2O_2 Treated

Class Interval in Ø Units	Class Wt.	Cumulative Wt.	Cumulative Percent Coarser
4.00	.026	11.441	
4.00- 4.99	.010	11.415	0.23
5.00- 5.99	.625	11.405	0.32
6.00- 6.99	2.535	10.780	5.78
7.00- 7.99	1.690	8.245	28.94
8.00- 8.99	1.060	6.555	42.71
9.00- 9.99	.955	5.495	51.97
10.00-10.99	.880	4.540	60.32
11.00-11.99	1.035	3.660	68.01
12.00-12.99		2.625	77.06
13.00-13.99			

L-10-1 H_2O_2 Treated

Class Interval in Ø Units	Class Wt.	Cumulative Wt.	Cumulative Percent Coarser
4.00	.002	6.822	
4.00- 4.99	.035	6.820	0.03
5.00- 5.99	.405	6.785	0.54
6.00- 6.99	.960	6.380	6.48
7.00- 7.99	.815	5.420	20.55
8.00- 8.99	.450	4.605	32.50
9.00- 9.99	.675	4.155	39.09
10.00-10.99	.450	3.480	48.99
11.00-11.99	.510	3.030	55.58
12.00-12.99		2.520	63.06
13.00-13.99			

BR-3-2 H_2O_2 Treated

Class Interval in Ø Units	Class Wt.	Cumulative Wt.	Cumulative Percent Coarser
< 4.00	.003	13.948	
4.00- 4.99	.145	13.945	0.02
5.00- 5.99	.625	13.800	1.06
6.00- 6.99	2.445	13.175	5.54
7.00- 7.99	2.140	10.730	23.07
8.00- 8.99	1.320	8.590	38.42
9.00- 9.99	1.165	7.270	47.88
10.00-10.99	1.015	6.105	56.23
11.00-11.99		5.090	63.51
12.00-12.99			
13.00-13.99			

BR-4b-1 H_2O_2 Treated

Class Interval in Ø Units	Class Wt.	Cumulative Wt.	Cumulative Percent Coarser
< 4.00	.005	5.605	
4.00- 4.99	.055	5.600	0.09
5.00- 5.99	.300	5.545	1.07
6.00- 6.99	.985	5.245	6.42
7.00- 7.99	.640	4.260	24.00
8.00- 8.99	.540	3.620	35.42
9.00- 9.99	.575	3.080	45.05
10.00-10.99	.360	2.505	55.31
11.00-11.99	.415	2.145	61.73
12.00-12.99		1.730	69.14

DC-7d-1 H_2O_2 Treated

Class Interval in Ø Units	Class Wt.	Cumulative Wt.	Cumulative Percent Coarser
< 4.00	.142	7.412	
4.00- 4.99	.075	7.270	1.92
5.00- 5.99	.495	7.195	2.93
6.00- 6.99	.750	6.700	9.61
7.00- 7.99	.865	5.950	19.72
8.00- 8.99	.695	5.085	31.40
9.00- 9.99	.700	4.390	40.77
10.00-10.99	.510	3.690	50.22
11.00-11.99	.520	3.180	57.10
12.00-12.99		2.660	64.11

P-6-1 H_2O_2 Treated

Class Interval in Ø Units	Class Wt.	Cumulative Wt.	Cumulative Percent Coarser
< 4.00	.052	9.682	
4.00- 4.99	.140	9.630	0.54
5.00- 5.99	.615	9.490	1.98
6.00- 6.99	1.555	8.875	8.34
7.00- 7.99	1.500	7.320	24.30
8.00- 8.99	1.070	5.820	39.89
9.00- 9.99	.770	4.750	50.94
10.00-10.99	.600	3.980	58.89
11.00-11.99	.805	3.380	65.09
12.00-12.99		2.575	73.40

P-7b-2 H_2O_2 Treated

Class Interval in Ø Units	Class Wt.	Cumulative Wt.	Cumulative Percent Coarser
< 4.00	.002	7.052	
4.00- 4.99	.025	7.050	.03
5.00- 5.99	.220	7.025	.38
6.00- 6.99	.855	6.805	3.50
7.00- 7.99	.855	5.950	15.63
8.00- 8.99	.795	5.095	27.75
9.00- 9.99	.835	4.300	39.02
10.00-10.99	.405	3.465	50.87
11.00-11.99		3.060	56.61
12.00-12.99			
13.00-13.99			

EXPLANATION OF PLATE I

Ectoprocts

Ramose Type 1

upper left; specimen encrusting _Petrocranis_ cf. _modesta_ (surface P-6-3, specimen number 32).
left middle; surface BR-3-1, specimen number 29.
left bottom; specimen encrusting _Myalina_ (surface P-6-2, specimen numbers 11 and 12).
upper right; washed residue P-6-2.
right middle; washed residue DC-6-2.
bottom right; surface DC-6-4, specimen number 10.

Ramose Type 2

top; washed residue BR-3-3.
left; surface P-6-2, specimen number 17.
right; surface DC-6-4, specimen number 15.

Ramose Type 3

left; surface P-6-3, specimen number 27.
right; washed residue BR-3-3.

Ramose Type 4

surface DC-6-5, specimen number 9.

Fenestrate Type 1

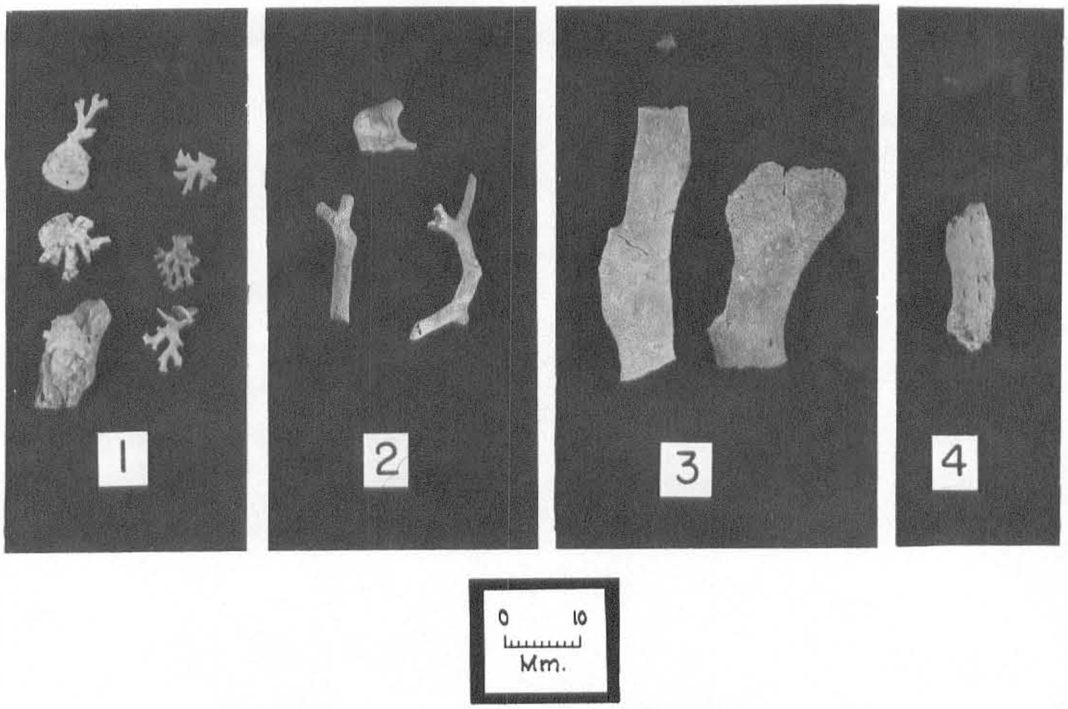
upper left; surface DC-6-4, specimen number 36.
upper right; surface DC-6-2, specimen number 13.
lower; washed residue DC-6-2.

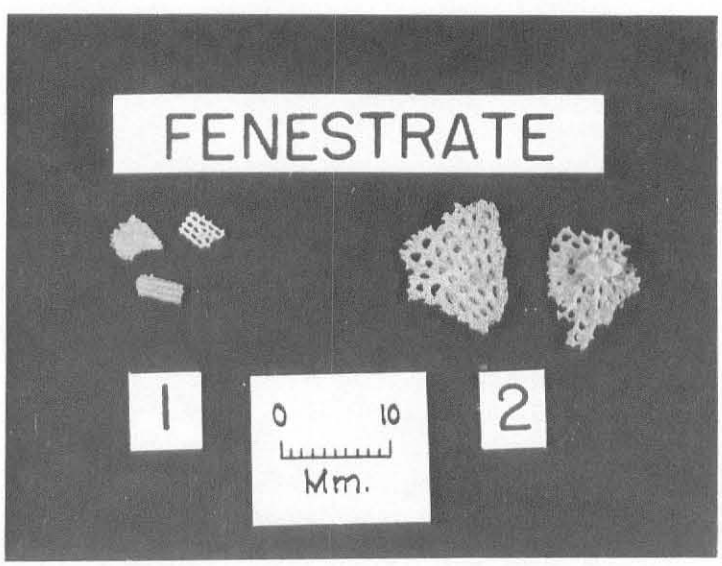
Fenestrate Type 2

left; surface P-6-3, specimen number 2.
right; surface BR-3-3, specimen number 29.

PLATE I

RAMOSE





EXPLANATION OF PLATE II

Fig. 1. Horizontal burrows probably *Chondrites* (just below surface P-7b-3).

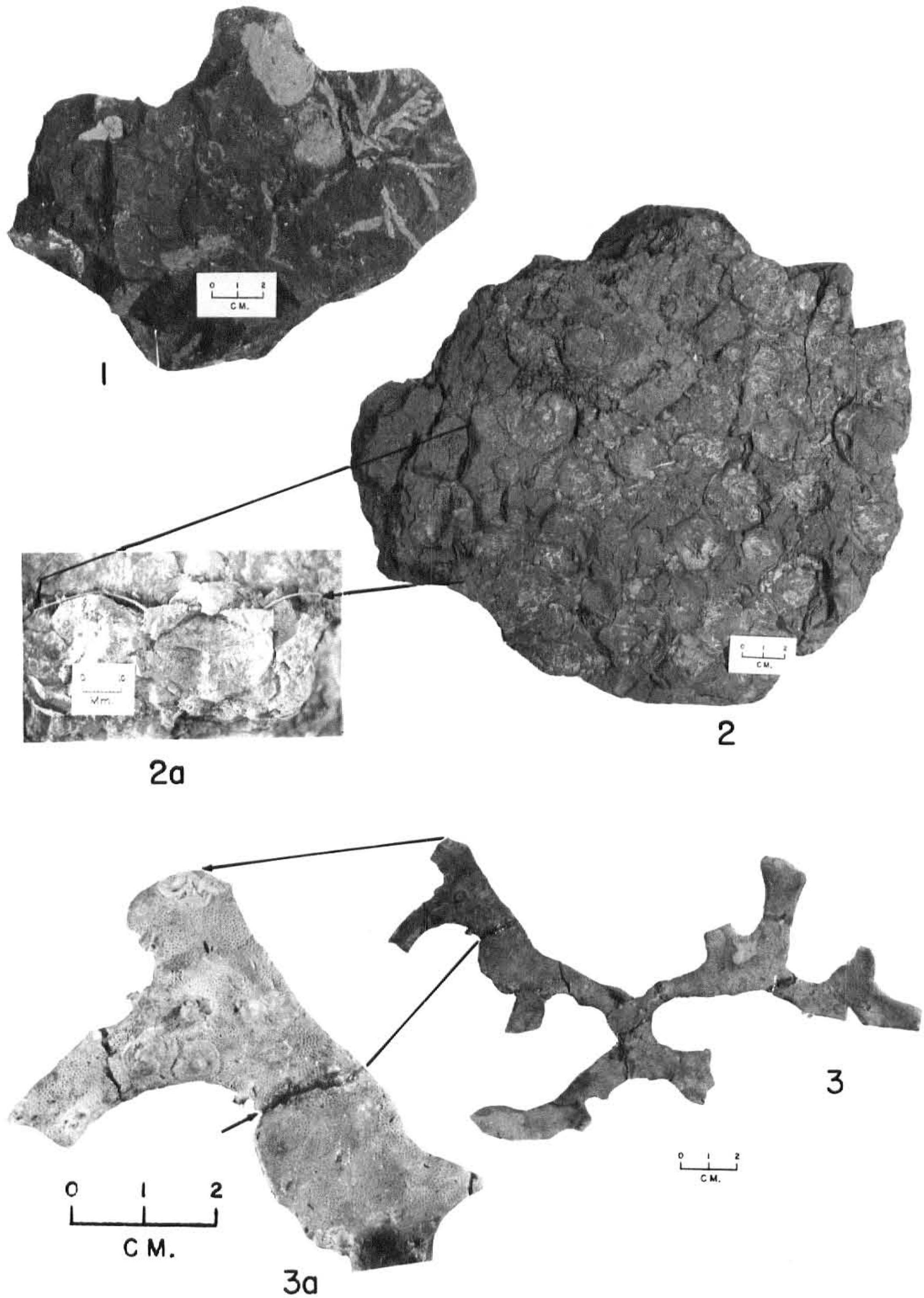
2. Surface W-8-1.

2a. *Linoproductus* cf. *magnispinus* (Surface W-8-1) showing supporting spines.

3. Ramose type 3 ectoproct reconstructed from fragments on surface W-8-5, specimen number 14.

3a. Enlargement of 3 showing episymbionts *Petrocrania* cf. *modesta* and ramose type 1 ectoprocts attached to this organism.

PLATE II



PALEOECOLOGIC STUDY OF PART OF THE
HUGHES CREEK SHALE (LOWER PERMIAN)
IN NORTH-CENTRAL, KANSAS

by

GALE RICHARD YARROW

B. S., Kansas State University, 1967

AN ABSTRACT OF A MASTER'S THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Geology

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1974

ABSTRACT

A paleoecologic investigation of two beds in a limestone-mudstone sequence of the Hughes Creek Shale Member of the Foraker Limestone from five localities was undertaken to determine 1) vertical differences in biota and petrology of the interval and 2) effects of the Nemaha Anticline (lateral differences) on the fossil assemblages and petrology.

By mapping bedding surfaces at $\pm$ 3 centimeter intervals biotic diversity, equitability, and Q mode analysis comparisons between beds at one locality and between localities indicate that the interval represents part of a cyclothem. Similarities are greatest between adjacent localities at one equilvalent surface. Using the total interval a different pattern was noted with localities on opposite sides of the Nemaha Anticline having more similarity than adjacent localities indicating that this structure may have affected the organisms. Ecologic parameters (high level suspension feeding behavior and infaunal mode of life) indicate no difference between localities suggesting species substitution in the ecologic framework.

The lower bed is a mudstone and the upper an argillaceous micritic limestone. Percent insolubles are lower but weight percent organic carbon is significantly higher in the upper bed. Median grain size increases upward in the lower bed and is significantly smaller in the upper bed. Illite is the dominant clay mineral at all localities with chlorite ranking second except at weathered localities where vermiculite is second. Based on insolubles, percent organic carbon, and median grain size, the upper bed is interpreted as being formed in a poorly oxygenated environment nearer the strand line. Little lateral differences are noted in petrologic properties except those attributed to weathering.