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PALEOECOLOGY OF SOME UPPER PENNSYLVANIAN
BENTHIC INVERTEBRATES

by

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B. S., Kansas State University, 1970

613-8301

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

1973

Approved by:



Major Professor

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INTRODUCTION

Purpose of Investigation

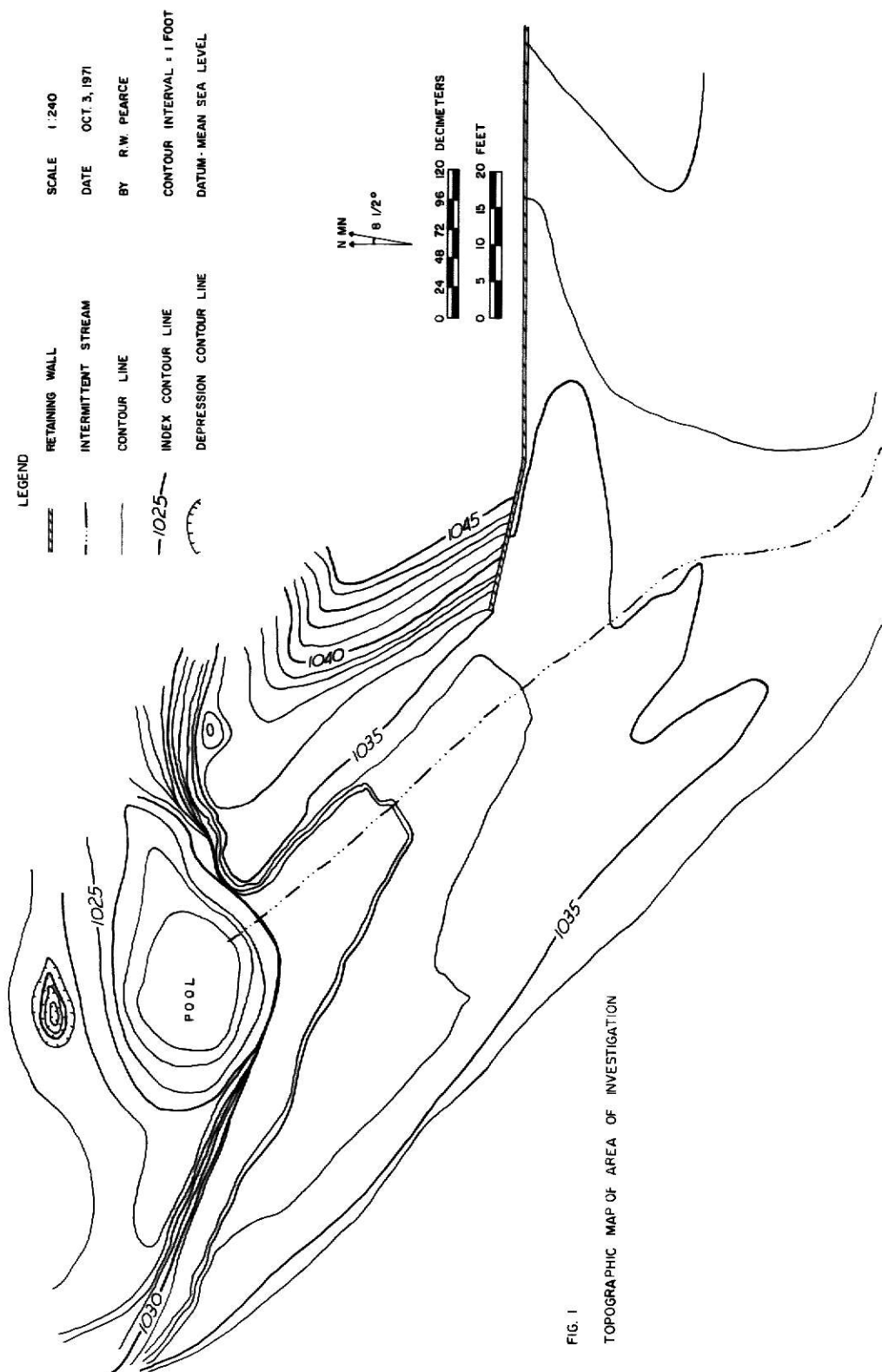
This investigation is a paleoecologic study of four bedding planes in a thin interval of Upper Virgilian limestone in Atchison County, Kansas and was undertaken to determine (1) compass orientations of megafossils for paleowave and/or paleocurrent determinations, (2) animal-substrate relationships, (3) fossil density and diversity and (4) carbonate petrology of both the matrix surrounding and within "in situ" invertebrate fossils. By comparing data in this study with data on similar Recent organisms, the substrate preferences and environmental parameters of "in situ" invertebrate fossils can be inferred and their ecology better understood.

Location

The area is in the NE 1/4 NW 1/4 Sec. 12, T. 5 S., R. 17 E. in Atchison County, Kansas, and is in the spillway of Atchison County Lake (fig. 1) approximately five miles southeast of Horton, Kansas (fig. 2). Several hundred square meters of four separate limestone beds in the Reading Limestone Member of the Emporia Formation are exposed making it an ideal locality for bedding plane studies.

Previous Investigations

Smith (1904) named the Reading Limestone Member of the Emporia Formation. The type locality, as designated by Moore (1935), is near



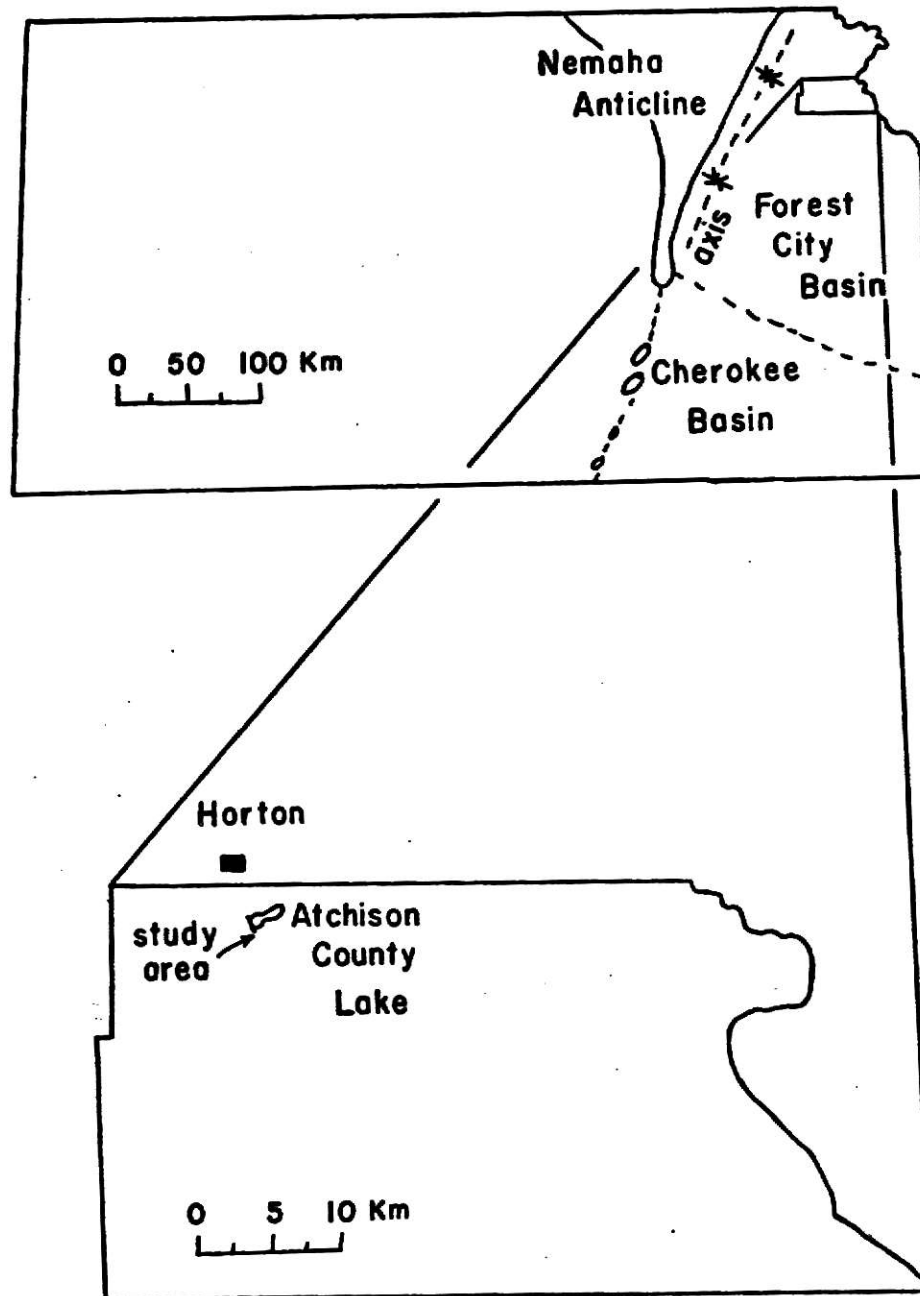


Fig. 2. Geographic and structural location of study area.

Reading, Lyon County, Kansas. Scott (1973) is completing a master's thesis on benthic community succession in the Emporia Formation at this locality.

GEOLOGIC SETTING

Structure

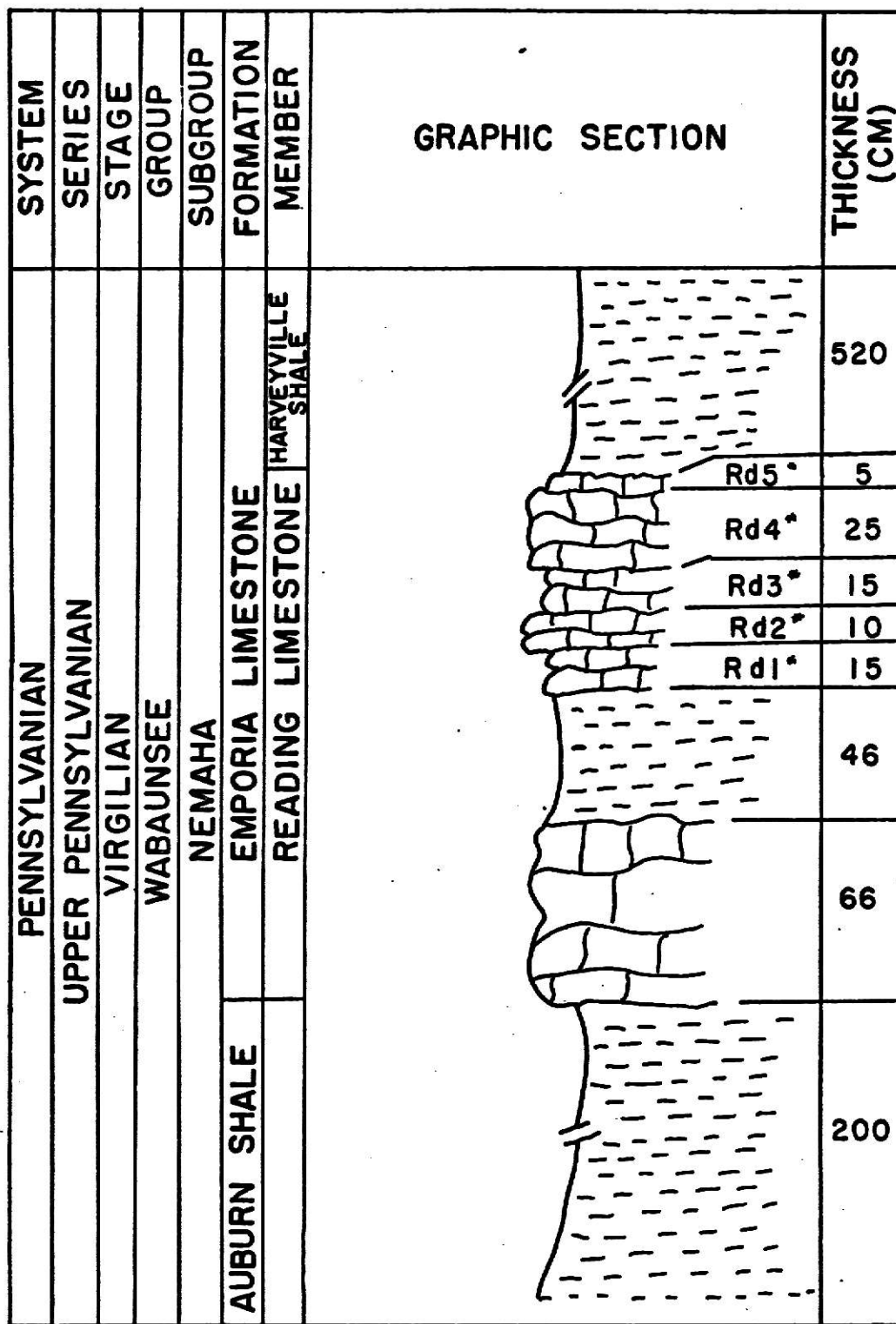
The area is in the southwest part of the Forest City Basin (fig. 2). The Reading at this locality has a strike of $N50^{\circ}E$ and dip of $0.26^{\circ} N40^{\circ} W$ which was determined using the three point method (Donn and Shimer, 1958). These values are reasonable because the study area is east of the axis of the Forest City Basin (fig. 2). Three prominent sets of vertical joints exist in the Reading at this locality, striking $N55^{\circ} W$, $N10^{\circ} E$ and $N60^{\circ} E$.

Stratigraphy

Units studied comprise the upper limestone beds (fig. 3) of the Reading Limestone Member of the Emporia Formation.

Lithology. -- These limestone beds are gray (5Y5/2), medium bedded dense biomicrites and are separated into five distinct beds. These five beds will be referred to in ascending order as Rd1, Rd2, Rd3, Rd4, and Rd5. There are no lithologic differences in the five beds. Only the lower four beds (Rd1 through Rd4) were studied because only a few square meters of Rd5 were exposed.

Biotic Aspects. -- Wilkingia cf. elliptica and Pteronites cf. peracuta are in inferred life position in the bottom four beds. Echinaria cf. moorei is in inferred life position in Bed Rd2. Associated remains common to all



SCALE 1 cm = 61 cm (1 in. = 2 ft.)

* Designations used throughout the thesis for these beds.

Fig. 3. Generalized stratigraphic section at study area.

horizons are linoproductid and chonetid brachiopods, Enteleles cf. hemipli-
catus; bellerophontid and meekospirid gastropods; fenestrate and ramose
 bryozoan debris; and crinoid columnals. Edmondia sp. and pectinoid and
 myalinid bivalves are also on horizon Rd1. Lophophylidiids occur on horizon
 Rd3 and Ditmopyge sp. pygidia, lophophylidiids and echinoid spines also
 occur on Rd4.

Depositional Environment. --Comparing the assemblage of organisms
 in these four beds with the Derbyia assemblage of Hattin (1957) as summarized
 by Moore (1964), there is strong evidence for an offshore environment of
 nearly normal salinity. This assemblage also denotes an area of weak
 turbulence resulting from weak wave activity. High percentage of micrite
 (73-96 percent) in the beds also supports these interpretations.

METHODS OF INVESTIGATION

Field Procedure

The initial step was to construct a topographic (fig. 1) and geologic
 (fig. 4) map. Because of the small area and the need for detail, plane table
 and alidade were used.

To facilitate studies of organism density and diversity (Ager, 1963)
 an overlay of square meter quadrats was prepared. The grid was numbered
 as in Figure 5 so that a unique number existed for each square meter over
 the entire outcrop. A table of random numbers was then used to obtain a
 square meter area for each of four horizons. If the random number selected

FIG. 4

GEOLOGIC MAP OF AREA OF INVESTIGATION

HORIZONTAL SCALE 1:240

DATE OCT. 3, 1971

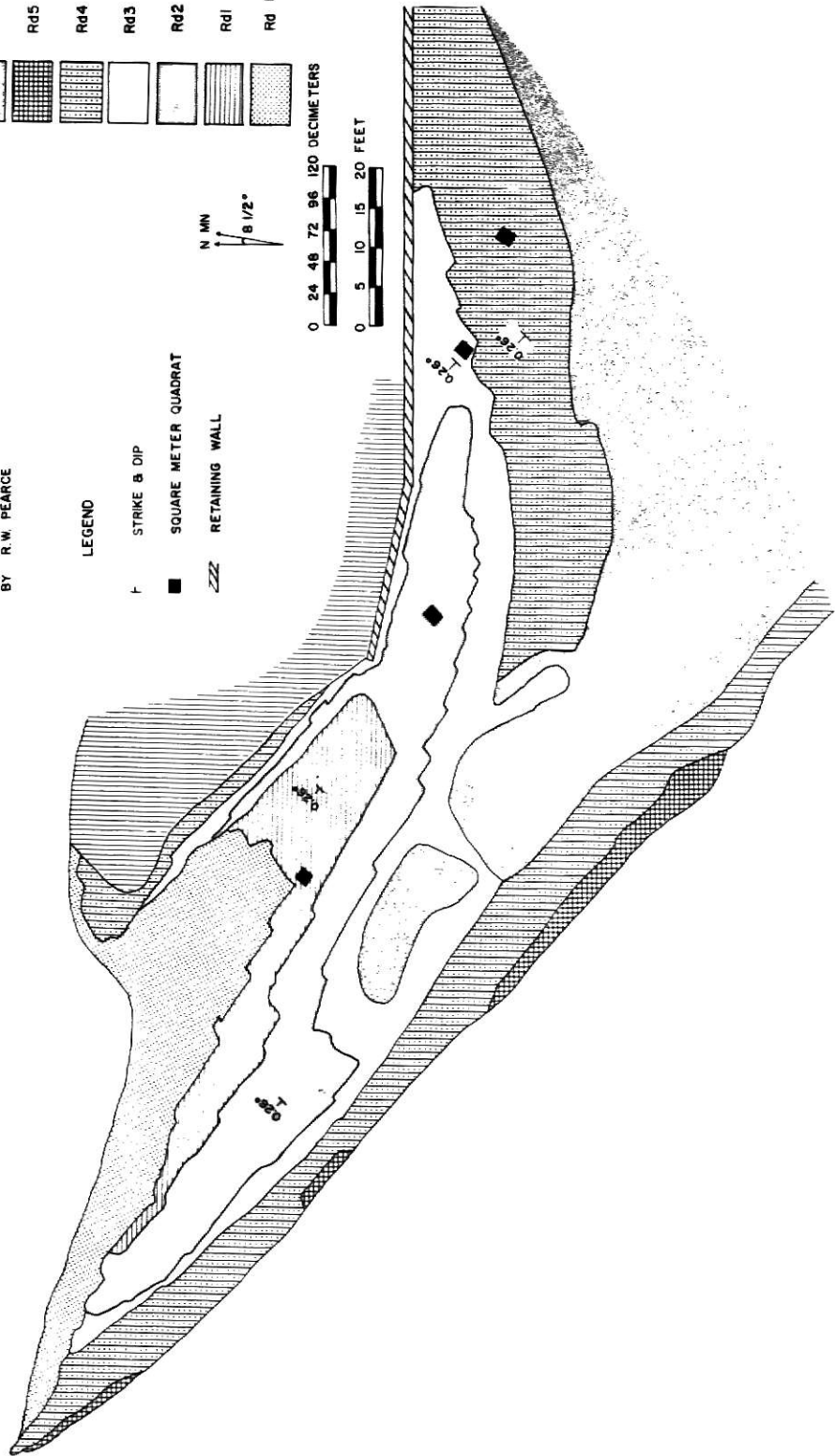
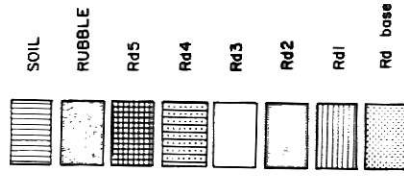
BY R.W. PEARCE

LEGEND

— STRIKE & DIP

■ SQUARE METER QUADRAT

--- RETAINING WALL



	1	2	3	4	5	6	7	8
1								
2					2-5			
3								
4							4-7	

Fig. 5. Numbering System for Grid Overlay.

a square meter on a horizon on which a previous square meter was selected, another number was picked until one square meter was selected for each horizon. The megafossils in these square meters were then mapped (App. V-VIII).

The third step was to go over the bedding planes using the reference grid system, one square meter at a time, measuring the compass orientation (fig. 6) of conspicuous megafossils. Those measured were *linoproductions*, *Echinaria* cf. *moorei* and *Enteletes* cf. *hemiplicatus*; *Wilkingia* cf. *elliptica* and *Pteronites* cf. *peracuta*; and crinoid columnals. Only those columnals three times longer than wide were used because there is a greater chance that they reflect paleowave and/or paleocurrent directions. The above mentioned organisms were chosen because their orientation may reflect paleowave and/or paleocurrent direction either during life for feeding purposes (those in inferred life position) or after death, may reflect hydrodynamic

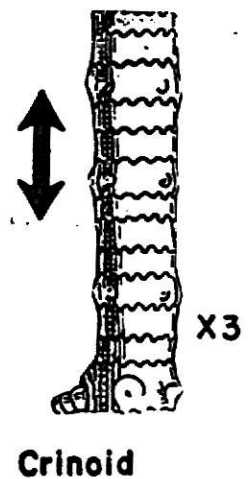
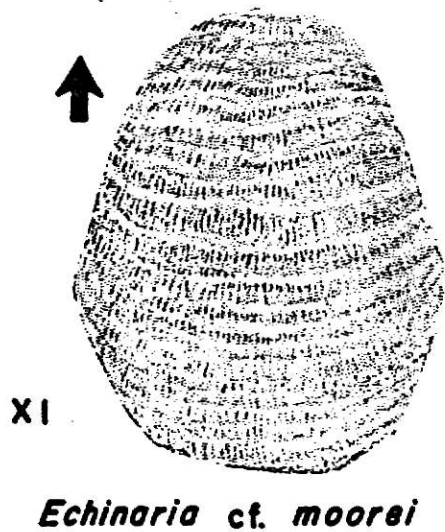
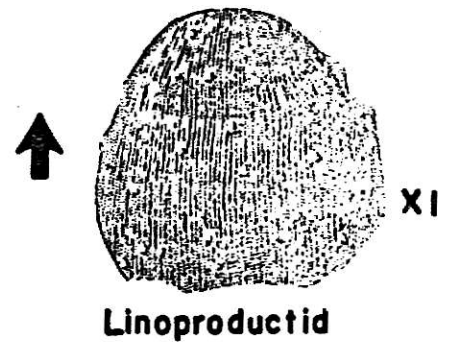
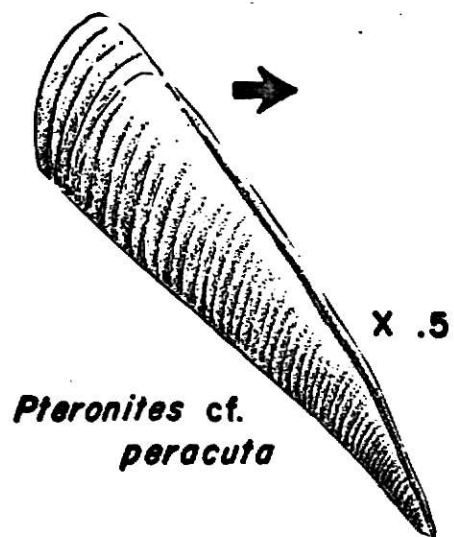


Fig. 6. Relationship between recorded compass bearing and fossil orientation. (Fossil drawings after Moore, Lalicker, and Fischer, 1962. Heavy arrow shows direction measured.)

stability.

Several specimens of "in situ" organisms, Wilkingia cf. elliptica, Pteronites cf. peracuta and Echinaria cf. moorei, were collected for study of associated lithology and study of their angular relations with substrate. Only those specimens in inferred life position were collected because these are the organisms in which animal-substrate relationships would be meaningful. To determine whether there were lateral and vertical changes in associated lithologies and orientation, 41 samples were collected from the entire exposed area of the four beds (Rd1 through Rd4).

Laboratory Procedure

The orientation to bedding of each sample of Pteronites cf. peracuta and Wilkingia cf. elliptica (fig. 7) was measured in the laboratory (see Tables 6 and 7) so as to determine the inferred life position and ultimately some ecological aspects of these bivalves.

Thin sections of seven "in situ" specimens (one from Rd1, two from Rd2, one from Rd3, and three from Rd4) were prepared using a Hillquist thin section machine. Two thin sections for each specimen were made, one of the rock surrounding the skeleton or internal mold and the other of the rock within it.

Thin sections were necessary to study the microfossils and carbonate petrology of the rock. A rectangular area averaging 5 square centimeters, covering as much of the thin section as possible was drawn on the slides and approximately 1200 points evenly distributed over the rectangular area were

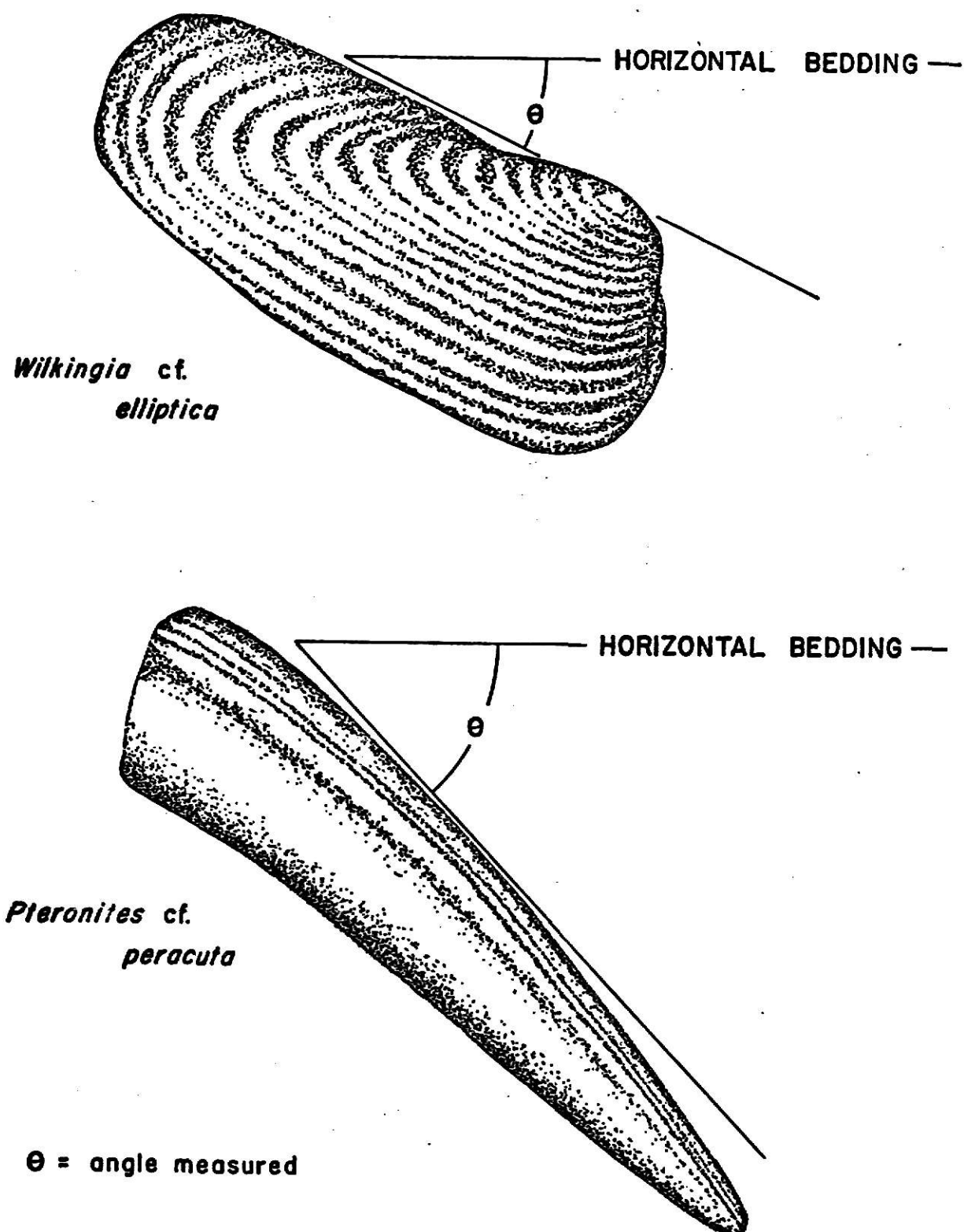


Fig. 7. Angular relationship between organism and bedding (substrate).

identified and counted.

Percentages of insoluble residue were obtained from Scott (1972). He started with 25 gram samples in preweighed 1000 ml. beakers. Hydrochloric acid (6 N) was added gradually until violent effervescence ceased. Then acid was added and the samples were allowed to stand 24 hours at room temperature. Samples were then oven dried, weighed and the difference taken between beaker plus sample and empty beaker weight to obtain the insoluble residue weight. This was then converted to a percentage of the total sample weight.

From field observations, brachiopods in inferred life position (Rudwick, 1970) at this locality were identified as Echinaria (Muir-Wood and Cooper, 1960) cf. E. moorei (Dunbar and Condra, 1932). Pholadomyoid and mytiloid bivalves are in inferred life position. The pholadomyoid is identified as Wilkingia (Wilson, 1959) cf. W. elliptica (Phillips, 1836). The mytiloid is identified as Pteronites (M'Coy in Griffith, 1844) cf. P. peracuta (Shumard, 1858).

POST MORTEM EFFECTS

Pteronites cf. peracuta and Wilkingia cf. elliptica are in inferred life position and show little post mortem changes other than in alteration of shell mineralogy and shell solution. All specimens of these two genera were articulated.

Detailed square meter studies on horizon Rd1 (Table 1) revealed

Table 1.

Articulation Data

Horizon Rd1:

<u>Taxa</u>	<u>Left Valve</u>		<u>Right Valve</u>	
	<u>Number</u>	<u>Percent</u>	<u>Number</u>	<u>Percent</u>
<u>Edmondia</u> sp.	6	54.5	5	45.5
myalinids	4	33.0	8	67.0

Horizon Rd4:

<u>Taxa</u>	<u>Broken Valves</u>		<u>Pedicle Valves</u>	
	<u>Number</u>	<u>Percent</u>	<u>Number</u>	<u>Percent</u>
chonetids	30	36.1	35	66.0

<u>Brachial Valves</u>	
<u>Number</u>	<u>Percent</u>
18	34.0

differences in percentage of right and left valves for Edmondia sp. and myalinids. However, the sample sizes are so small that a Chi-square test (App. IV) revealed no significant differences. There is no field evidence of breakage of these two taxa. Lack of breakage plus equal numbers of right and left valves are indications for little, if any, transportation (West, 1970). Lack of breakage and of drilled holes or pits in the fossils leads to the conclusion that selective predation was probably slight (Fagerstrom, 1964). Sufficient breakage or articulation data were not obtained from horizons Rd2 and Rd3 to warrant consideration.

Articulation and breakage data on chonetid brachiopods were obtained from horizon Rd4 (Table 1). There were no apparent articulated specimens;

however, the hydrodynamically stable position of this skeleton is with the pedicle valve up. Most specimens were buried so that it was impossible to distinguish articulated from disarticulated specimens (i.e., whether the brachial valve was under the pedicle valve). This could explain why 32 percent more pedicle than brachial valves were observed.

More than 30 percent of the chonetid specimens were broken. Most shells were broken in half which I believe to be caused by outcrop weathering. Specimens are partly weathered out of the bed and broken in the process.

Specimens of Wilkingia cf. elliptica are preserved as internal molds with no original shell remaining. Both Pteronites cf. peracuta and Echinaria cf. moorei are preserved skeletons of original or altered shell mineralogy.

DIVERSITY

For diversity calculations I assumed that each taxon is of a single species because in the Recent two species of the same genera seldom compete with one another (Turpaeva, 1957). Diversity and equitability are calculated from those organisms with preservable hard parts, molds of hard parts or internal molds of hard parts. Soft bodied organisms which must have existed here are not included. Johnson (1964), in studying Recent marine benthos, found that on the average only 30 percent of the fauna consist of species with preservable hard parts and I assume this value to be valid for these limestone beds. It is assumed that diversity and equitability based on preserved organisms provide a basis for comparison of the four beds.

Diversity is calculated to provide a single value to define the species composition of an assemblage. More species in an assemblage and equally abundant numbers of individuals in each species yield higher diversity.

Using data obtained from one square meter maps for each bedding plane (Table 2), the Shannon-Wiener function for species diversity (Margalef, 1957, and Mac Arthur & Mac Arthur, 1961) was calculated for each horizon (Table 3). The function is $H(s) = -\sum_{i=1}^s p_i \log_2 p_i$, where s is the total number of species in a sample and p_i is the proportion of individuals in the i^{th} species ($i = 1, 2, 3, \dots, s$).

Equitability is calculated for the same reason as diversity; to define the species composition of a community. It is a ratio of (1) the hypothetical number of species, with equal numbers of individuals in each species, required to produce the existing diversity, to (2) the actual number of species with their actual numerical composition. For example, in horizon Rdl the diversity $H(s)$ is 2.54 and the number of species is 12. There are unequal numbers of individuals in each species. To produce this same diversity (2.54) would require only 8 species with equal numbers in each species. The equitability ϵ is the ratio of the numbers of species, 8 : 12, or 0.67. This equitability coefficient ϵ is calculated for each horizon (Table 3). Stated mathematically $\epsilon = s'/s$, where s' is a hypothetical completely equitable distribution (i.e., equal numbers of individuals in each species) needed to produce a diversity equal to the observed one (s' is obtained from a table in Lloyd and Ghelardi, 1964) and s is the actual number of

Table 2

Horizon	Taxa	No. of ind. / m ²	P _i	-p _i log ₂ p _i
Rd4	lophophylidiids	4	.048	.209
	chonetids	64	.762	.299
	<u>Enteleles cf. hemiplicatus</u>	1	.012	.076
	linoproductids	3	.357	.173
	meekospirids	2	.024	.130
	<u>Straparollus sp.</u>	2	.024	.130
	<u>Pteronites cf. peracuta</u>	3	.036	.173
	echinoid	1	.012	.076
	<u>Ditmopyge sp.</u>	4	.0476	.209
Rd3	lophophylidiids	1	.091	.252
	bryozoans	1	.091	.252
	linoproductids	1	.091	.252
	<u>Derbyia sp.</u>	1	.091	.252
	<u>Echinaria cf. moorei</u>	1	.091	.252
	meekospirids	1	.091	.252
	<u>Edmondia sp.</u>	1	.091	.252
	<u>Pteronites cf. peracuta</u>	3	.273	.628
	crinoid	1	.091	.252
Rd2	linoproductid	3	.188	.452
	<u>Enteleles cf. hemiplicatus</u>	2	.125	.375
	<u>Echinaria cf. moorei</u>	1	.063	.203
	meekospirids	4	.250	.472
	<u>Straparollus sp.</u>	1	.063	.203
	<u>Pteronites cf. peracuta</u>	1	.063	.203
	<u>Wilkingia cf. elliptica</u>	3	.188	.452
	crinoid	1	.063	.203
Rd1	<u>Derbyia sp.</u>	1	.013	.080
	<u>Enteleles cf. hemiplicatus</u>	1	.013	.080
	linoproductids	12	.150	.412
	chonetids	1	.013	.080
	<u>Straparollus sp.</u>	4	.050	.216
	bellerophontids	4	.050	.216
	cephalopods	1	.013	.080
	<u>Edmondia sp.</u>	14	.175	.101
	pectinoids	26	.325	.528
	myalinids	7	.088	.307
	<u>Wilkingia cf. elliptica</u>	7	.088	.307
	<u>Pteronites cf. peracuta</u>	2	.025	.133

species observed. A high equitability (near 1) denotes an environmentally stable situation. Lower equitability results from one or more of the following: (1) lower environmental stability (Lloyd and Ghelardi, 1964), (2) transportation effects, and/or (3) data prejudice due to sampling errors and/or diagenetic effects.

Insoluble residue data (fig. 8) are used as a parameter of environmental stability. High percentages of insolubles suggest terrigenous influx indicating low environmental stability whereas the opposite is true for horizons with lower percentages of insolubles. One would expect a lower diversity (Donahue, et al., 1972) where the percentages of insolubles are high. Equitability, diversity, and percentage of insolubles for each bed are related graphically in Figure 8. Equitability and diversity are similar. Using a Monroe 1775 calculator, a linear regression was calculated for diversity and equitability of each horizon (Table 3). The correlation coefficient is 0.887, which is significant at the .12 level, indicating some degree of correlation. Figure 8 also reveals that the curve for diversity and percentages of insoluble residue are mirror images and have a high negative correlation. Linear regression results in a correlation coefficient of -0.99, which is significant at the .01 level, and indicates a high degree of negative correlation¹ between diversity and percent of insolubles. As the percentage of insoluble residue (i.e., environmental instability) increases, diversity decreases; this agrees with Donahue, et al., (1972) who stated that diversity is a function of environmental stability.

¹ $P \geq 0.990$ with 2 degrees of freedom.

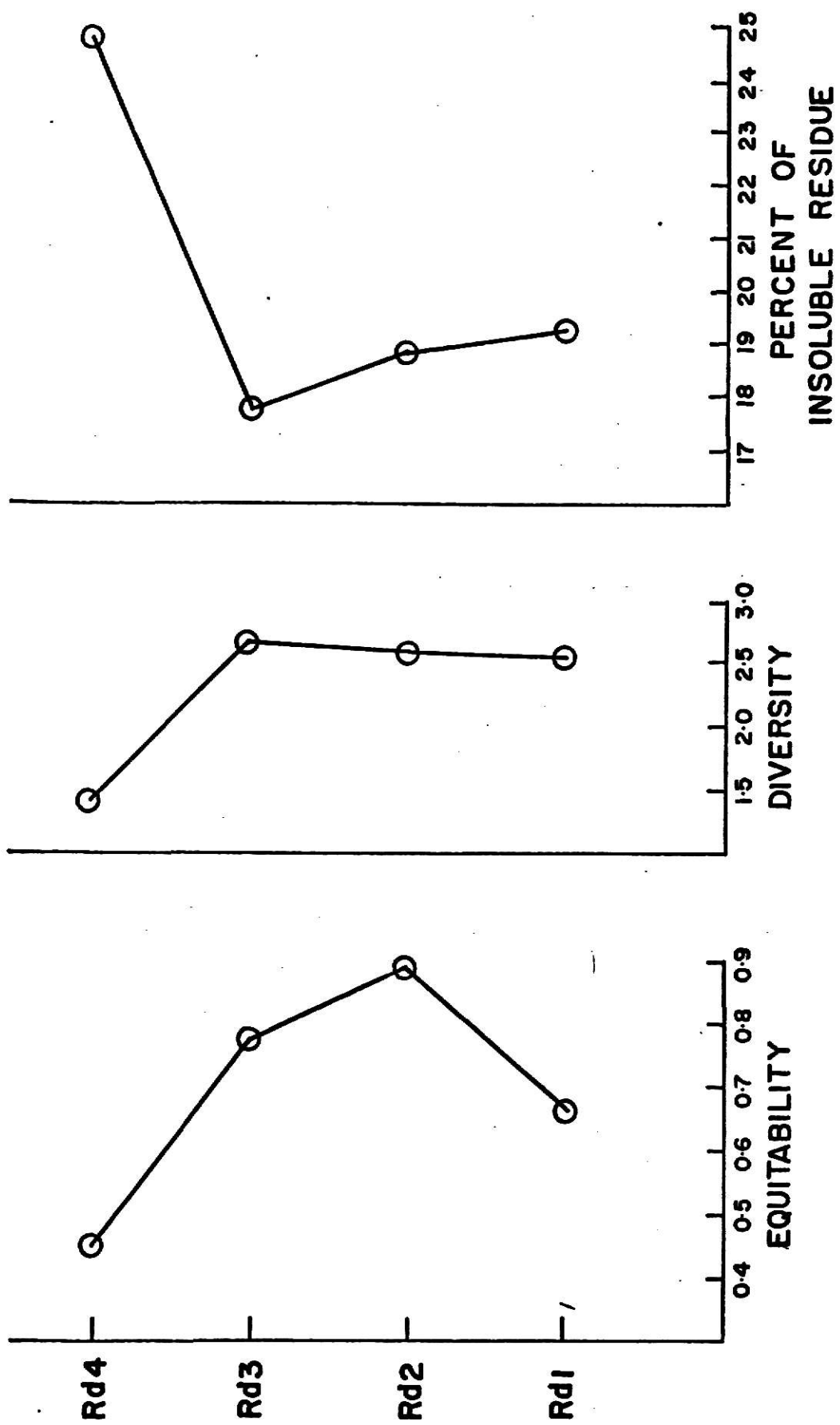


Fig. 8. Equitability, diversity and percent of insoluble residue for each bed.

Table 3

Diversity and Equitability Values

<u>Bed</u>	<u>H (s)</u>	<u>s</u>	<u>s'</u>	
Rd4	1.47	9	4	.444
Rd3	2.64	9	7	.778
Rd2	2.56	8	7	.875
Rd1	2.54	12	8	.667

DENSITY

Horizon Rd1 contains 100 individuals per square meter (fig. 9A), horizon Rd2 has 16 (fig. 9B), horizon Rd3 has 11 (fig. 9C) and horizon Rd4 has 84 (fig. 9D). Spatial distribution of these organisms is on the maps in Appendices V-VIII.

Organisms in each bed were classified by feeding type and mode of life (Table 4) to provide a useful denominator for comparison of the four horizons. The percentage of individuals of each feeding type for each horizon are shown graphically in Figure 10. Density of organisms is greater on horizons Rd1 and Rd4 and percentages of epifaunal suspension feeders are greater than percentages of infauna on these same two horizons which may indicate a gap in deposition at the tops of beds Rd1 and Rd4. A gap in deposition on the order of a few months to a few years at these two points could have allowed more skeletons to accumulate at the tops of these beds. Epifaunal organisms could survive through the period of non-deposition, but would accumulate at the sediment-water interface and not through a bed as

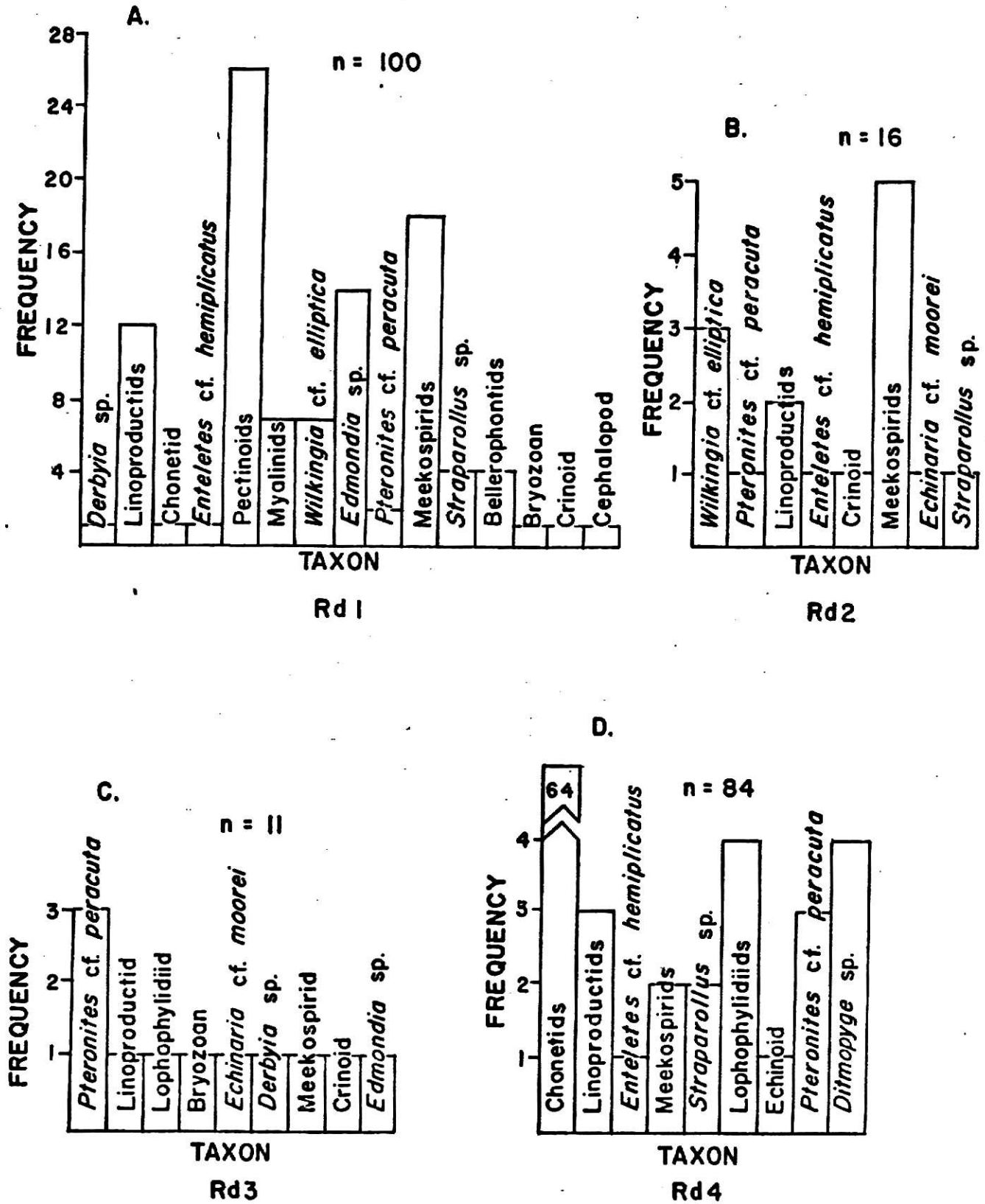


Fig. 9. Number of individuals per square meter.

Table 4
Organism Feeding Types

<u>Organism</u>	<u>Feeding Type</u>	<u>Reference</u>
lophophylidiids	epifaunal suspension	West, 1970, p. 100
bryozoans	epifaunal suspension	West, 1970, p. 100
chonetids	epifaunal suspension	West, 1970, p. 116
linoproductids	pseudo-infaunal suspension	West, 1970, p. 116
<u>Echinaria</u> cf. <u>moorei</u>	infaunal suspension	*
<u>Enteleles</u> cf. <u>hemiplicatus</u>	epifaunal suspension	*
<u>Derbyia</u> sp.	epifaunal suspension	West, 1970, p. 116
bellerophontids	grazer	West, 1970, p. 100
<u>Straparollus</u> sp.	grazer	West, 1970, p. 100
pectinoids	epifaunal suspension	West, 1970, p. 100
<u>Wilkingia</u> cf. <u>elliptica</u>	semi-infaunal filter	West, 1970, p. 100
<u>Pteronites</u> cf. <u>peracuta</u>	semi-infaunal filter	West, 1970, p. 100
<u>Edmondia</u> sp.	infaunal suspension	*
myalinids	epifaunal suspension	*
crinoids	epifaunal suspension	West, 1970, p. 100
<u>Ditmopyge</u> sp.	deposit	West, 1970, p. 100

*I have no literature to substantiate these classifications. They were based on shell morphology interpretations.

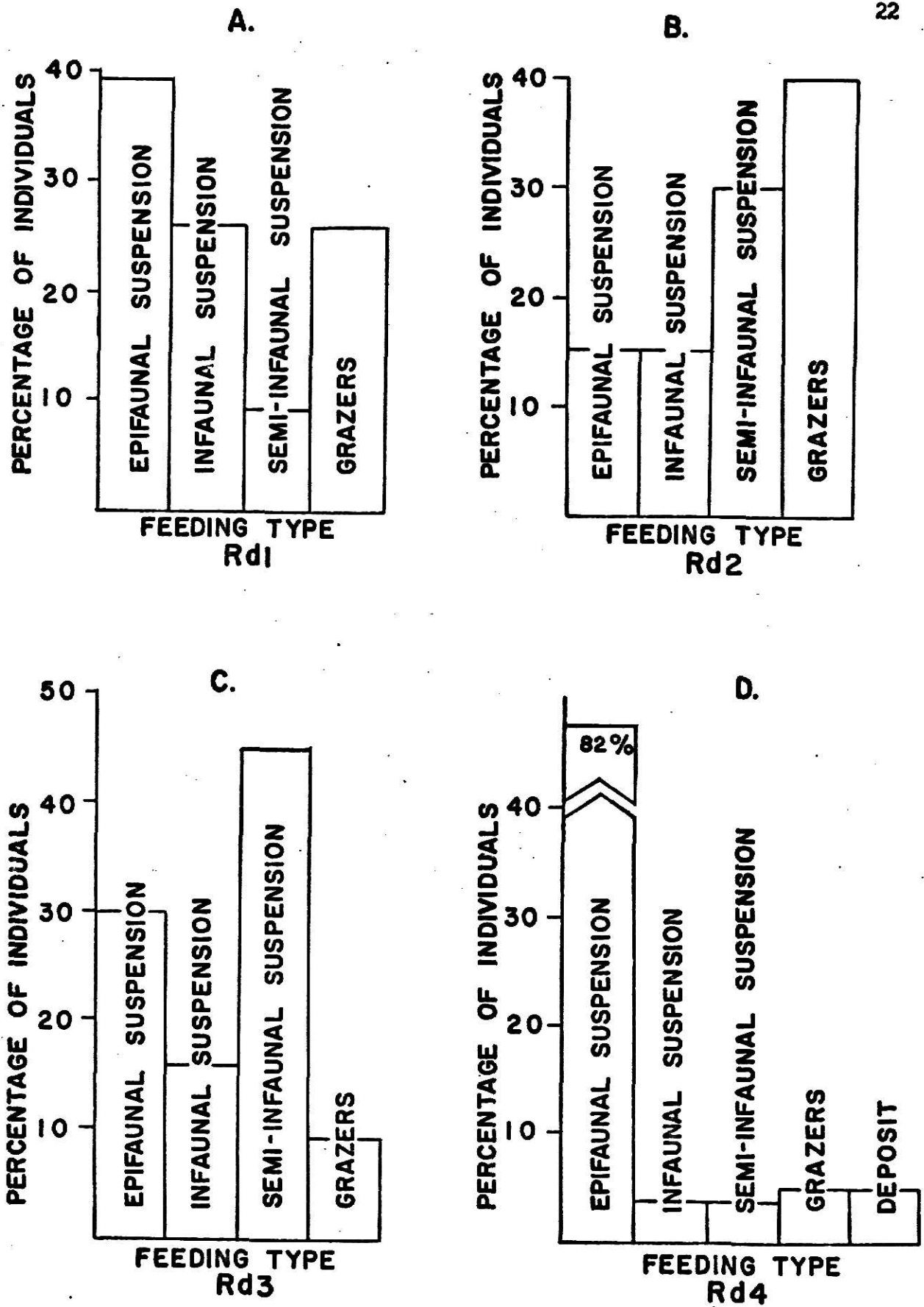


Fig. 10. Composition of bedding planes in terms of feeding type.

they would if deposition were to continue. Because Rd1 and Rd4 have higher percentages of insolubles, it might be thought that feeding mechanisms would be clogged, but the organisms found on these beds occur elsewhere in shale units, indicating they were types which resisted clogging. Meekospirids, pectinoids, Derbyia sp. and myalinids on horizon Rd1 have also been found in mudstone and shale units by West (1970) and Moore (1964). Linoproductids on horizons Rd1 and Rd2 are also in the shale unit just below. Chonetids and Ditmopyge sp. on horizon Rd4 have also been recorded in shale units by Moore (1964). Lophophylidiids on horizon Rd4 have been identified in the Hughes Creek Shale by the author. Another reason which supports these hiatuses is that the substrate possibly had become too firm for burrowing (i. e., low percentages of infauna in these two beds) and thus more favorable for attached suspension feeding epifauna. The burrowing organisms in Rd1 and Rd4 (Wilkingia cf. elliptica and Pteronites cf. peracuta are morphologically adapted to life in soft substrates (Stanley, 1970). A period of non-deposition would possibly give the substrate time to become too firm for burrowing by these organisms.

ORIENTATION

Compass orientation directions of megafossils (fig. 6) were recorded on each horizon over the entire extent of the outcrop to aid in determining possible paleocurrent and/or paleowave directions. Rose diagrams were constructed using the method described by Nagle (1967). This method consists

of dividing the compass directions into twelve classes of 30° intervals and plotting a point a scalar distance from the origin along the mid line of the class interval (i.e., out the 15° line for the class interval from 0° to 30°) that represents the number of individuals aligned in this class interval. After points are plotted for each class, the points are connected consecutively from each class interval to the next thus forming a rose diagram (figs. 11-14).

Fossils both in presumed life position and not in presumed life position were recorded. It was assumed that those not in presumed life position were possibly oriented by waves and/or currents at the time of or soon after death. Possibly those in inferred life position would indicate preferential orientation because of biological requirements such as feeding and respiration.

A Rayleigh's test of randomness (Reyment, 1971, p. 41-45) was performed on each of the 13 rose diagrams (figs. 11-14) to test whether orientation was random. Rayleigh's test statistic, z , is $V^2 + W^2 / N$, where $V = \sum_{i=1}^N \cos \alpha_i$, $W = \sum_{i=1}^N \sin \alpha_i$ ($i = 1, 2, 3, \dots, N$), α_i is the angle measured and N is the total number of angles measured. A table of critical z values (Reyment, 1971, p. 192) was used. In terms of this statistic diagrams from all four horizons proved to be the result of random orientation. Therefore, it is not possible to postulate paleowave or paleocurrent directions.

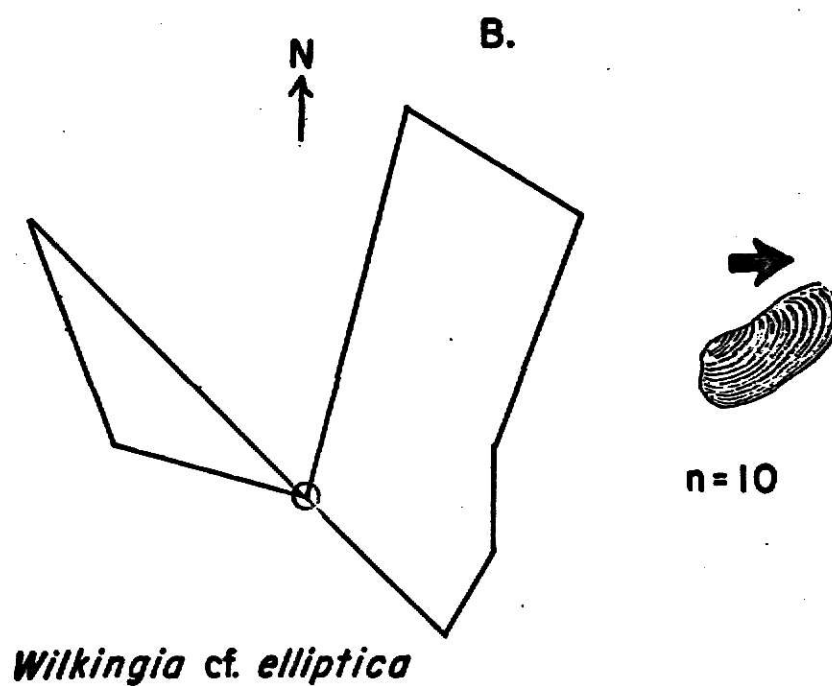
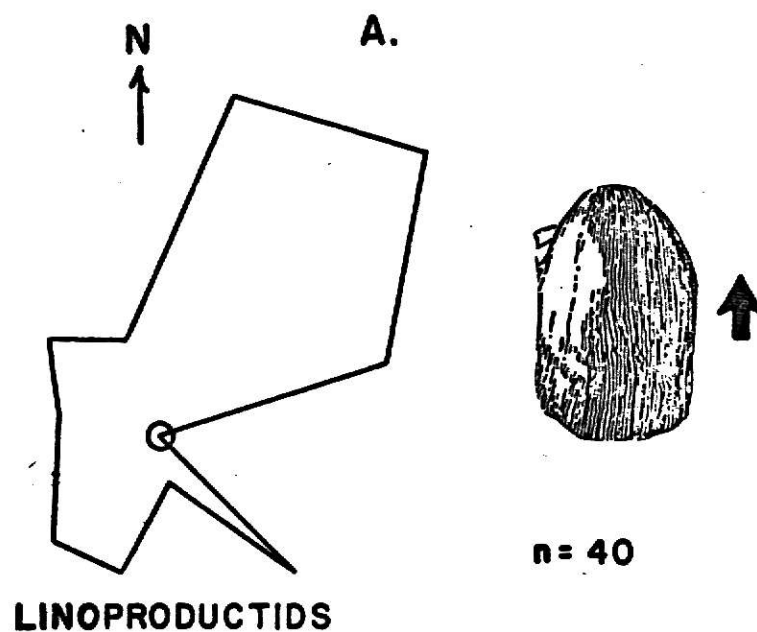


Fig. 11. Orientation of fossils from Horizon Rd1.
(Heavy arrow shows direction measured.)

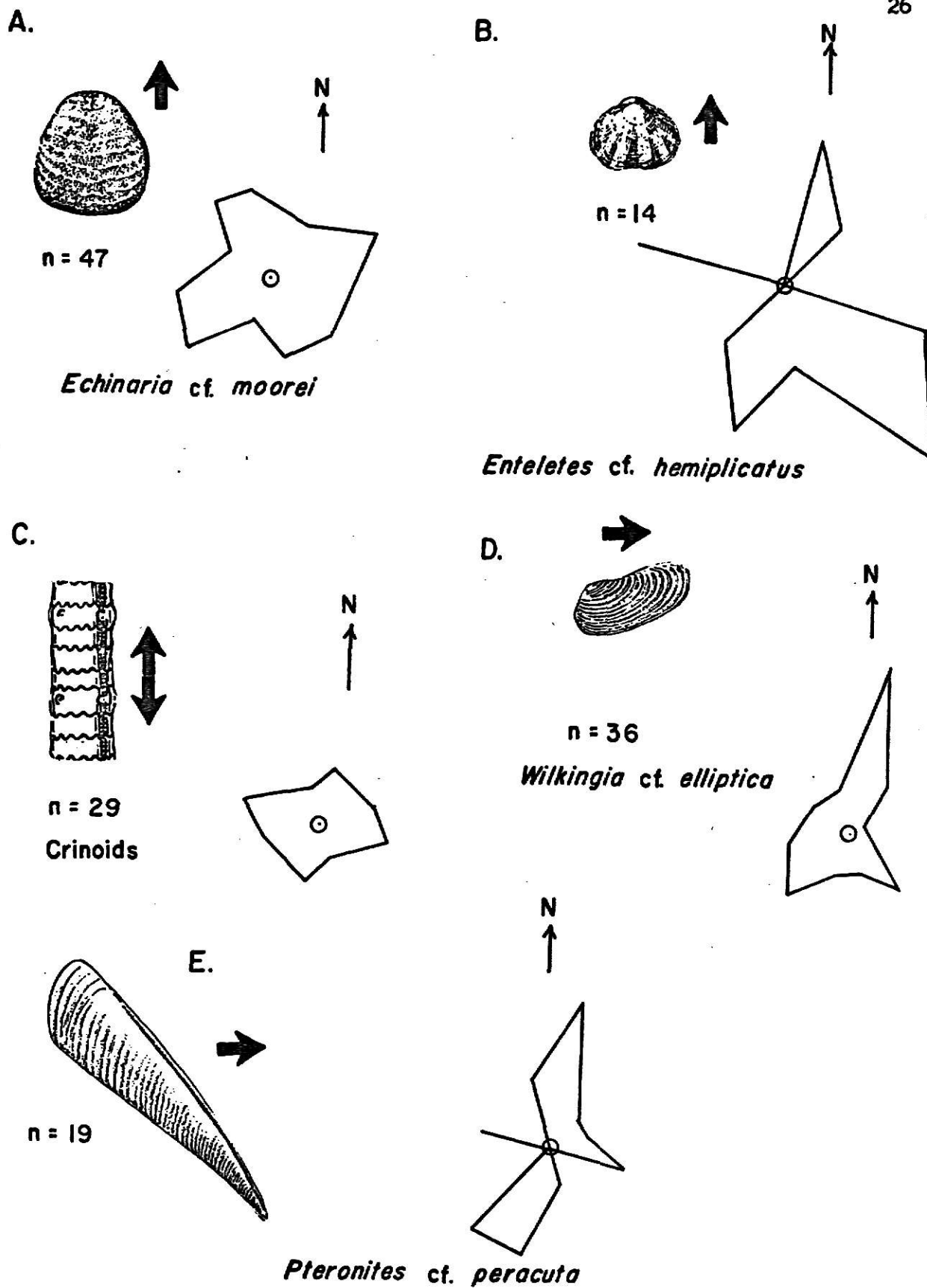


Fig. 12. Orientation of fossils from Horizon Rd2.
(Heavy arrow shows direction measured.)

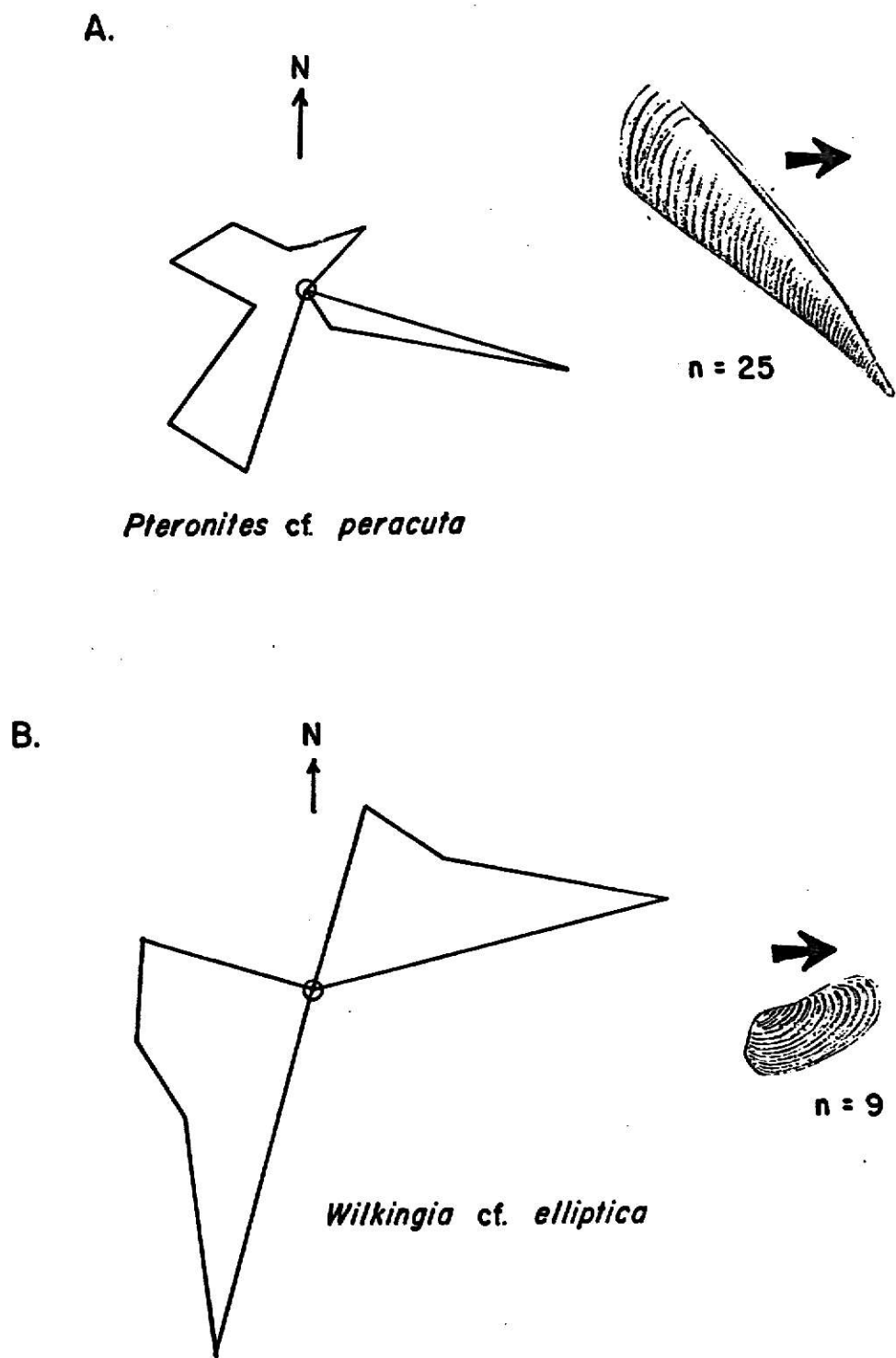


Fig. 13. Orientation of fossils from Horizon Rd3.
(Heavy arrow shows direction measured.)

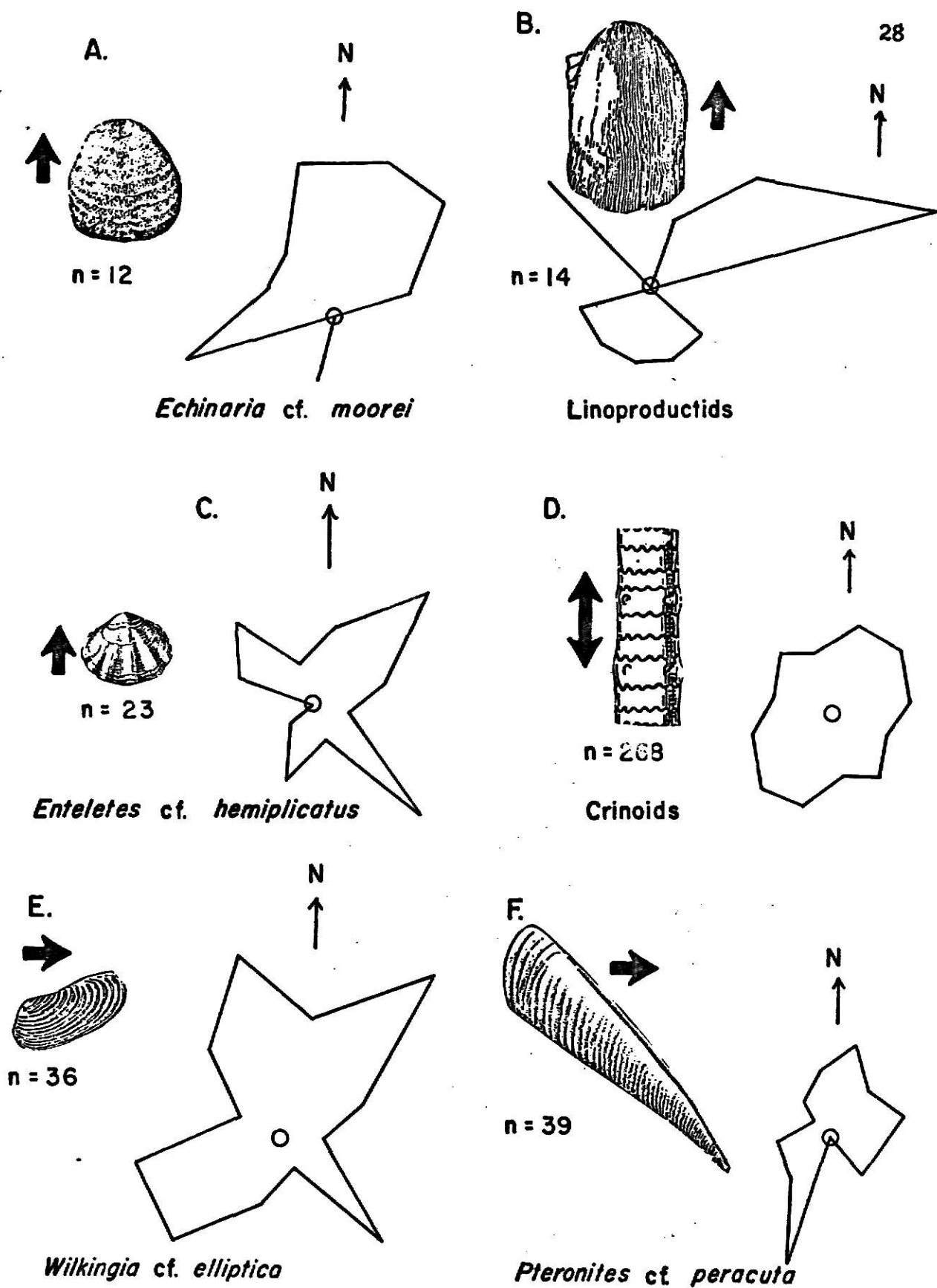


Fig. 14. Orientation of fossils from Horizon Rd4.
(Heavy arrow shows direction measured.)

RELATIONS OF ORGANISM TO SUBSTRATE

Phylum Mollusca Linne, 1758
 Class Bivalvia Linne, 1758
 Subclass Anomalodesmata Dall, 1889
 Order Pholadomyoida Newell, 1965
 Superfamily Pholadomyacea Gray, 1847
 Family Pholadomyidae Gray, 1847
 Genus Wilkingia Wilson, 1959
Wilkingia cf. W. elliptica (Phillips, 1836)

Morphology. -- This genus is characteristically oval to subcylindrical (at the beaks) in cross section and elongate lengthwise (Plate I, fig. 1). Growth lines are well developed creating broad, rounded concentric folds. The hinge area is edentulous. A shallow sulcus extends from the beak region to the mid portion of the ventral margin. Small radial rows of papilli extend outward from the beak region. The species is diagnosed as Wilkingia cf. W. elliptica (Phillips, 1836). It is characterized by being about twice as long as high (Table 5) and it also has a shallow sulcus from the umbonal region towards the ventral margin. The valves have non-bifurcating, prominent concentric ribs (Wilson, 1959).

Life Position. -- The life position of Wilkingia cf. elliptica is inferred to be with its plane of commissure vertical and its long axis at an angle to bedding (fig. 7). It is comparable to Grammysia obliqua (Bambach, 1971) and Modiolus modiolus (Stanley, 1970) in shell morphology. M. modiolus is semi-infaunal and lives in soft substrates. Plate I, figure 2 is a photograph of an "in situ" Wilkingia cf. elliptica and the organism is inferred to be in life position. It is believed that it was semi-infaunal, i. e., a portion of the

Table 5

Wilkingia cf. elliptica Size Data

<u>Length (cm)</u>	<u>Height (cm)</u>	<u>Width (cm)</u>	<u>Length/height ratio</u>	<u>Height/width ratio</u>
8.6	2.6	3.2	3.31	0.81
6.3	3.1	2.7	2.03	1.15
7.5	3.4	2.8	2.21	1.21
6.9	2.8	2.7	2.46	1.04
5.3	2.3	1.9	2.30	1.21
7.1	3.4	3.4	2.09	1.00
8.7	3.7	3.0	2.35	1.23
4.6	2.6	1.9	1.77	1.37
6.4	2.8	2.4	<u>2.29</u>	<u>1.17</u>
Mean =			2.31	Mean = 1.13
Standard deviation =			.424	.172
Standard error of the mean =			.141	.057

organism extended above the sediment-water interface because all specimens had a part of the skeleton above the top of the bed (Plate I, fig. 2).

Angular orientation with bedding was only measured on those specimens where part of the matrix could be broken away from the specimen which permitted accurate angular measurement as in Figure 7. The mean angular relationship is 26° with a standard deviation of 8° and a standard error of the mean of 1.94° (Table 6). I believe the life position of this organism to be the mean \pm the standard deviation or between 18° and 34° from the horizontal.

To determine if variations in angular relations existed between horizons, a series of t-tests were performed between horizons Rd1 and Rd2, Rd2 and Rd4, and Rd1 and Rd4 (Table 6). Differences might have existed because of differences in quantity of terrigenous influx (inferred from insolubles data) from bed to bed. The magnitude of terrigenous influx or local turbidity might have had some biological effects causing the bivalves to favor different orientations under different conditions. From Table 6 there are no statistically significant differences in measurements from the three horizons; however, sizes of samples are so small and unequal that differences may not show up statistically.

Petrology Surrounding Internal Mold. -- Relationships between Wilkingia cf. elliptica and surrounding lithologies were studied extensively in beds Rd1, Rd2, and Rd4. Thin section point count analyses were used and the rock type indicated in terms of the Folk (1959) classification.

Table 6

Wilkingia cf. elliptica Angular Relation to Bedding

<u>Horizon from which Sample was Derived</u>	<u>Angle to Bedding (in degrees)</u>
Rd4	10 23 30 21 46 25 21
Rd3	No Data
Rd2	29 31 23 24 30 19 23
Rd1	38 27 <u>23</u>
$\bar{x} = 26.1$	

Standard deviation = 7.9

Standard error of the mean = 1.94

<u>Horizon</u>	<u>ΣX</u>	<u>ΣX^2</u>	<u>\bar{X}</u>	<u>n</u>	<u>t-test</u>
Rd1	88	120.7	29.3	3	0.97*
Rd2	179	119.7	25.6	7	0.59*
Rd4	176	726.9	25.1	7	0.11*

* Not significant at .05 level.

Wilkingia cf. elliptica in all beds is surrounded by biomicrite (App. I). These biomicrites average 85.8 percent orthochems and are dominantly micrite (averaging 82.7 percent) with some chert, spar, microspar and limonite. Allochems consist entirely of skeletal grains which are dominantly crinoid fragments, bivalve shell fragments, bryozoans and ostracodes. Size of allochem grains averages 0.56 mm. Biomicrites indicate that the sediments were deposited in an area where currents were too weak or short-lived to winnow away micrite (1-4 micron) particles (Folk, 1959, p. 24). High percentages of micrite in these limestones (averaging 82.7 percent) indicate a substrate at the time of deposition of carbonate mud with lesser quantities of shell debris. Some micrite has recrystallized (12.0 percent average) to microspar.

Petrology of Internal Mold. --Lithologies of the internal molds of Wilkingia cf. elliptica vary between specimens. Molds from horizons Rd1 and Rd2 contain micrite (less than 10 percent allochems) with mean allochem grain sizes of 0.19 mm and 0.58 mm respectively (App. I). These allochems consist mainly of bivalve shell fragments, ostracodes, bryozoans and ophal-mids. A crinoid columnal (1.0 mm in diameter) is the largest allochem in the specimen from Rd1. A bivalve fragment (0.7 mm by 4.0 mm) is the largest allochem in the specimen from Rd2. This means that the shell gape after death must have been at least 1.0 mm in the specimen from Rd1 and 0.7 mm in the one from bed Rd2 to have allowed these allochems to enter. Orthochems are dominantly micrite (92.9 percent average) with some spar, chert, microspar and limonite.

The specimen from Rd4 contains biomicrite (greater than 10 percent allochems) with a mean allochem grain size of 0.73 mm. Allochems consist entirely of fossil grains of dominantly bryozoans, crinoid fragments, ophal- mids, ostracodes and brachiopod shell fragments. The largest allochem is a crinoid columnal (1.7 mm by 2.5 mm). Thus the minimal shell gape must have been at least 1.7 mm in order for this clast to have entered. This larger gape may explain why this mold is biomicrite as opposed to the micrites found in Rd1 and Rd2. The wider gape allowed more and larger clasts to enter after death. Micrite is the dominant orthochem in this internal mold (78.1 percent) with chert, limonite, spar, microspar and pyrite.

Adaptation of Morphology to Substrate. --Length, width and height of nine specimens of Wilkingia cf. elliptica (fig. 15) were measured (Table 5). These specimens were collected from float along the stream below the out- crop. Specimens of float were used because desired measurements required complete removal of matrix. Length to height and width to height ratios were calculated. Stanley (1970, p. 50) indicated that bivalves adapted for burrow- ing in soft substrates have length to height ratios ranging from 1.0 to 3.5 and height to width ratios ranging from 1.0 to 3.8. Specimens of Wilkingia cf. elliptica have length to height ratios ranging from 1.8 to 3.3 and height to width ratios ranging from 0.81 to 1.37 (Table 5). Table 5 shows that all values except one height to width ratio fall within Stanley's ranges, supporting the inference that the substrate was soft. This one value that falls out of the range is probably due to post-depositional compaction.

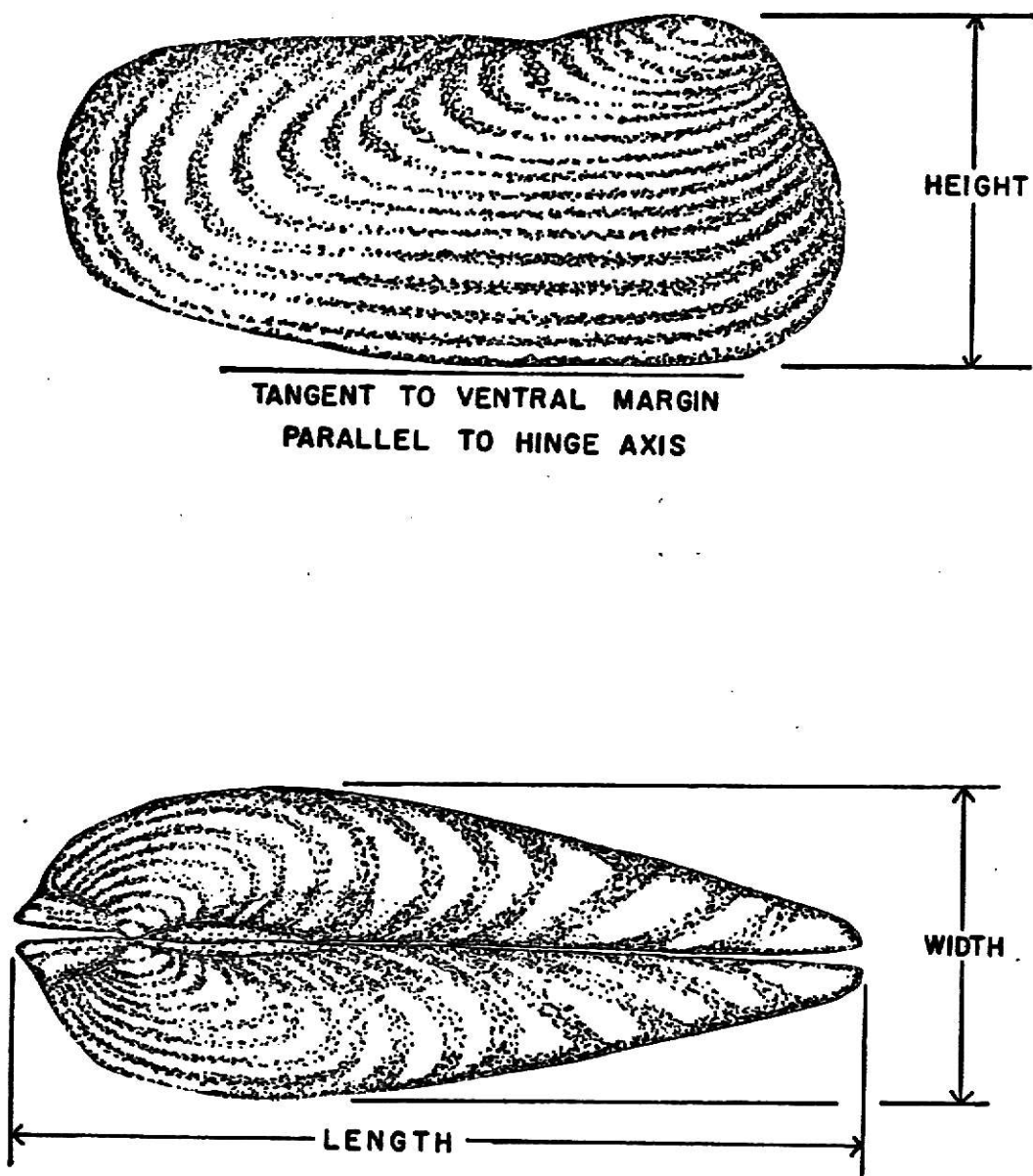


Fig. 15. Length, width and height measurements on *Wilkingia* cf. *elliptica*.

Wilkingia cf. elliptica lacks a pedal gape. The foot is assumed to have extended through the ventral margin area where maximum valve opening would occur. This area is where a tangent to the ventral margin is parallel to the hinge axis (fig. 15). In correlating this position of pedal emergence with inferred life position Stanley (1970, p. 47) suggested the organism moved dominantly forward during burrowing.

Shell ribbing probably hindered rapid burrowing, but was not an ecological disadvantage because it may have aided the anchoring and stabilizing of the organism in the substrate.

Subclass Pteriomorphia Beurlen, 1944
Order Mytiloida Ferussac, 1822
Superfamily Pinnacea Leach, 1819
Family Pinnidae Leach, 1819
Genus Pteronites M'Coy in Griffith, 1844
Pteronites cf. P. peracuta (Shumard, 1858)

Morphology. --This genus is elongate and cuneiform (Plate I, fig. 3) with umbones near the pointed anterior. The valves have a smooth interior and lack exterior ornamentation except growth-lines. Nothing is known of internal structure (Moore, 1969). The species was determined to be Pteronites cf. P. peracuta (Shimer and Shrock, 1944) and is characterized by a nearly cylindrical shell and indistinct growth lines.

Life Position. --Inferred life position of Pteronites cf. peracuta is with the plane of commissure vertical and the long axis at an angle to bedding (fig. 7). This bivalve in inferred life position is in Plate I, figure 4.

Pteronites cf. peracuta is assumed to have been semi-infaunal with the posterior part above the sediment-water interface. No complete specimens were

observed; however, this assumption is made because some specimens were found with part of the posterior above the bedding plane (Plate I, fig. 4).

Measurements of the angular relationship of the long axis to bedding (fig. 7) are in Table 7. The mean angle is 62.8° with a standard deviation of 19° and a standard error of the mean of 3.82° . Life position of this organism is inferred to be the mean \pm the standard deviation or to range from 43.8° to 81.8° . As with Wilkingia cf. elliptica, a t-test was performed to determine if variations existed between beds. There is a significant difference (Table 7) and the specimens from Rd4 are oriented at a lower angle from the horizontal than those in Rd3. I believe this to be due to limited sample sizes.

Pteronites cf. peracuta and Pinna carnea are in the same family (Pinnidae) and are morphologically similar. Pinna carnea, an extant bivalve, is useful in inferring some habits of Pteronites cf. peracuta. A detailed study of Pinna carnea has been published by Yonge (1953) and the following comments are useable for Pteronites cf. peracuta. Pinna carnea assumes its life position at a very young stage and usually maintains this position until death and Pteronites cf. peracuta is assumed to have behaved similarly. Pteronites cf. peracuta is assumed to have been a very inept burrower, unable to reestablish itself if uprooted. It probably grew both upward and downward from its original position and was most likely byssally attached. Slight burrowing may have been possible by ejecting water downward from the anterior (pointed) end.

Petrology Surrounding Skeleton. --Specimens from horizons Rd3 and Rd4 are surrounded by biomicrite (App. II). These beds contain an average of 18.7 percent allochems and an average of 81.3 percent orthochems. Mean

Table 7

Pteronites cf. peracuta Angular Relations to Bedding

<u>Horizon from which Sample was Derived</u>	<u>Angle to Bedding (in degrees)</u>
--	--

Rd4	16
	82
	23
	77
	43
	65
	53
	67
	66
	56
	54
	49

Rd3	58
	83
	75
	80
	85
	86
	66
	65
	78
	<u>42</u>

Mean = 62.8

Standard deviation = 18.9

Standard error of the mean = 3.8

<u>Horizon</u>	<u>ΣX</u>	<u>ΣX^2</u>	<u>\bar{X}</u>	<u>n</u>	<u>t-test</u>
Rd1	793	58953	72.1	11	2.75*
Rd4	651	39619	54.3	12	

* Significant at .05 level.

allochem grain sizes are 0.64 mm and 0.96 mm respectively. Allochem fractions are composed entirely of fossil skeletal debris. Dominant skeletons are brachiopod shell fragments, bivalve shell fragments, Osagia sp., bryozoans and crinoid fragments. Micrite is the dominant orthochem (averaging 84.0 percent) with spar, microspar and limonite. Biomicrites suggest that this was a depositional area of weak currents and high micrite percentage (84.0 percent average) supports the inference that the substrate was carbonate mud. Diagenesis resulted in recrystallization of micrite to microspar (12.3 percent).

Petrology within Skeleton. --The specimen from Rd3 contains biomicrite that consists of more than 10 percent allochems with mean grain size larger than 1.0 mm. The majority (79.1 percent) of allochems are bivalve shell fragments (App. II) that seem to be of Pteronites cf. peracuta. Part of the skeleton above the substrate could have been broken off by physical and biological agents and have fallen into the lower part of the skeleton. This would widen the opening between valves permitting more and larger skeletal grains to be incorporated within the carbonate mud filling.

Pteronites cf. peracuta from Rd4 is filled with fossiliferous micrite (App. II) that has a mean allochem grain size of 0.59 mm. The majority of allochems are crinoid fragments, ophalmids, Osagia sp. and ostracodes. Micrite is the dominant orthochem (85.8 percent). Chert, spar, microspar, pyrite and limonite are present in small amounts. Micrite supports an inferred substrate of carbonate mud as a source for this filling. Recrystallization of micrite to microspar was slight (11.8 percent).

Adaptation of Morphology to Substrate. -- Pteronites cf. peracuta was probably well adapted to a soft substrate if comparison with Pinna carnea (Yonge, 1953) is valid. Pteronites cf. peracuta and Pinna carnea are similar in gross skeletal morphology in that both are tapered at the anterior and become increasingly wider in a posterior direction (Plate I, fig. 3). Posterior widening possibly helped stabilize the organism in the substrate.

Phylum Brachiopoda Dumeril, 1806
 Class Articulata Huxley, 1869
 Order Strophomenida Opik, 1934
 Suborder Productidina Waagen, 1883
 Superfamily Productacea Gray, 1840
 Family Echinoconchidae Stehli, 1954
 Subfamily Echinoconchinae Stehli, 1954
 Genus Echinaria Muir-Wood & Cooper, 1960
Echinaria cf. E. moorei (Dunbar & Condra, 1932)

Morphology. -- This genus is characterized by a large body cavity with a strongly curved pedicle valve (Plate I, fig. 5). Both valves have evenly spaced concentric rows of short tangential spines. The pedicle valve is sulcate and recurved anteriorly. The species was diagnosed as Echinaria cf. E. moorei (Dunbar and Condra, 1932) and is characterized by tangential spines arranged in 3 or 4 rows per band. The hinge line is slightly more than half the maximum width of the shell.

Life Position. -- Because little is known of the life habits of this genus, much has to be inferred from skeletal morphology and relationships of skeleton to matrix. In the field most specimens of this organism were in a hydrodynamically stable position with the pedicle valve up. However, a few specimens had their brachial valve up (Plate I, fig. 6) which is unstable hydro-

dynamically and with respect to gravity. Grant (1966) as summarized by Rudwick (1970) reconstructed a similar orientation for the Permian strophomenid Waagenoconcha. Such an orientation is biologically reasonable because had the organism rested on the brachial valve, the anterior commissure would have been buried in sediment making feeding and respiratory functions very difficult if not impossible. Because of a pronounced geniculation in most productids, it would be possible for most of the shell to be buried in soft, soupy sediment with the anterior commissure several millimeters or more above the sediment-water interface.

Petrology Surrounding Skeleton. --Specimens from beds Rd2 and Rd4 were studied to determine the characteristics of the rocks enclosing this brachiopod. The specimen from Rd2 is surrounded by biomicrite and the one from Rd4 by biomicrudite (App. III). Allochem percentage in Rd2 is 14.4 percent and in Rd4 is 26.8 percent. These allochem fractions are composed entirely of fossil skeletal debris dominated by crinoid fragments, bivalve shell fragments, brachiopod shell fragments and bryozoans. Mean grain size of allochem is 0.97 mm in Rd2 and 1.10 mm in Rd4. Micrite is the dominant orthochem with lesser amounts of spar and microspar (App. III). The high percentage of micrite (94.2 percent and 81.9 percent respectively) suggests a substrate of carbonate mud at the time of deposition. Recrystallization of micrite to microspar occurred in small amounts (8.9 percent average) in these two beds.

Petrology within Skeleton. --The specimen from Rd2 is filled with fossiliferous micrite (App. III) composed of 2.2 percent allochems and 97.8

percent orthochems. Allochems consist of fossil skeletal debris including bivalve shell fragments, ostracodes, opthalmids and gastropods and have a mean grain size of 0.41 mm. Micrite (97.9 percent) and microspar (2.1 percent) are the orthochems in this rock.

The specimen from Rd4 is filled with biomicrudite (App. III) consisting of 19.4 percent allochems with a mean grain size of 1.09 mm. All allochems are skeletal grains with bivalve shell fragments, crinoid fragments and bryozoans dominant. Orthochems are mainly micrite (97.1 percent) with some spar, chert, and limonite.

In both rocks micrite has recrystallized to microspar averaging 6.8 percent.

The probable cause for the specimen from Rd2 containing a fossiliferous micrite, whereas that from Rd4 is filled with biomicrudite is that the specimen from Rd2 is articulated, but that from Rd4 is not. The disarticulated specimen (a pedicle valve) allowed all sizes of allochems to enter, resulting in biomicrudite, while the articulated one did not, resulting in micrite.

Associated Organisms and Inferred Substrates

Opthalmids and paleotextularids are common in these four beds (App. I-III) and are considered to be environmentally similar to Recent opthalmids and textularids. Moore (1957) found opthalmids and textularids common in back reef environments of Florida by where water depth averages 16 meters and the substrate consists of carbonate mud. This is compatible with the petrologic data of the previous section.

Osagia sp. is abundant in horizon Rd4 with small percentages in Rd2 and Rd3. Osagia sp. is a consortium of Girvanella sp., a blue-green algae and Hedraites sp., a conuspirid foraminiferid (Henbest, 1963) that occurs in shallow water environments and probably indicates some agitation of the water. Because of the encrusting characteristics of Osagia sp. (encrustation usually completely surrounds the grain being encrusted) there must be sufficient energy to roll the grain around. This is compatible with the data of this study because there are greater percentages of Osagia sp. in Rd4 where higher insoluble residues indicate higher energy conditions.

Study of Echinaria cf. moorei, comparison of Wilkingia cf. elliptica and Pteronites cf. peracuta with modern counterparts, petrologic analysis and associated organisms all suggest that the substrate of these four beds of upper Reading limestone was soft carbonate mud with 5 percent to 20 percent skeletal grains in shallow open marine waters with mild agitation.

TROPHIC ANALYSIS

Turpaeva (1957) divided Recent benthic marine organisms into trophic groups according to the level (distance above the sediment-water interface) from which the organism feeds and Walker (1972) used this scheme to subdivide Paleozoic benthic marine communities (Table 8). A better understanding of the relationship between Wilkingia cf. elliptica, Pteronites cf. peracuta, Echinaria cf. moorei and associated organisms can be obtained by applying Turpaeva's classification to these fossil assemblages. The taxa, their respective trophic groups and reference used to classify the taxa into these

trophic groups are listed in Table 9.

Table 8

Trophic Groups		
<u>Turpaeva (1957)</u>	<u>Walker (1972)</u>	<u>Source of Food</u>
Swallower	Infaunal deposit	Food within bottom sediment
Collector	Epifaunal deposit, scavengers, brows- ing herbivores	Food on sediment surface
Filter-A	Low-level suspension	Food in water 1-3 mm above bottom
Filter-B	High-level suspension	Food in water 3 mm and higher above bottom
Awaiter	Passive suspension	Trap food from current of water some distance above bottom

According to Turpaeva (1957) each assemblage should have a dominant trophic group. Using data from detailed square meter studies, bar graphs of numbers of individuals in each trophic group for each horizon (fig. 16) indicate a dominant trophic group for each one. Filter-A feeders are dominant in Rd1, Filter-B in Rd2, Filter-B in Rd3 and Filter-A in Rd4.

Turpaeva also noticed that if the most dominant taxon belongs to one particular trophic group, then the second most dominant taxon belongs to a separate trophic group. This prevents interspecific competition of any limited resource by abundant taxa. This is true for the four horizons studied (figs. 18-20). In horizon Rd1 pectinoids of Filter-A group are most abundant with

Table 9

Trophic Groups of Organisms in this Study

<u>Organism</u>	<u>Turpaeva's (1957) Trophic Group</u>	<u>Reference</u>
lophophylidiids	Filter-B	Walker, 1972, p. 89
bryozoans	Awaiter	Walker, 1972, p. 84*
<u>Derbyia</u> sp.	Filter-A	**
linoproductids	Filter-B	Grant, 1966, p. 1067
chonetids	Filter-A	Rudwick, 1970, p. 91
<u>Enteleles</u> cf. <u>hemiplicatus</u>	Filter-A	**
meekospirids	Collector	Walker, 1972, p. 84
bellerophontids	Collector	Walker, 1972, p. 84
<u>Straparollus</u> sp.	Collector	Walker, 1972, p. 84
pectinoids	Filter-A	**
myalinids	Filter-A	**
<u>Wilkingia</u> cf. <u>elliptica</u>	Filter-B	Stanley, 1970, p. 27
<u>Edmondia</u> sp.	Filter-A	**
<u>Pteronites</u> cf. <u>peracuta</u>	Filter-B	Yonge, 1953
crinoids	Filter-B	**
<u>Ditmopyge</u> sp.	Collector	Walker, 1972, p. 87

* This group was classified by Walker (1972) as Filter-A but I interpret the feeding type as Awaiter (compare with Table 8).

** I have no literature to substantiate these classifications. They are based on shell morphology interpretations.

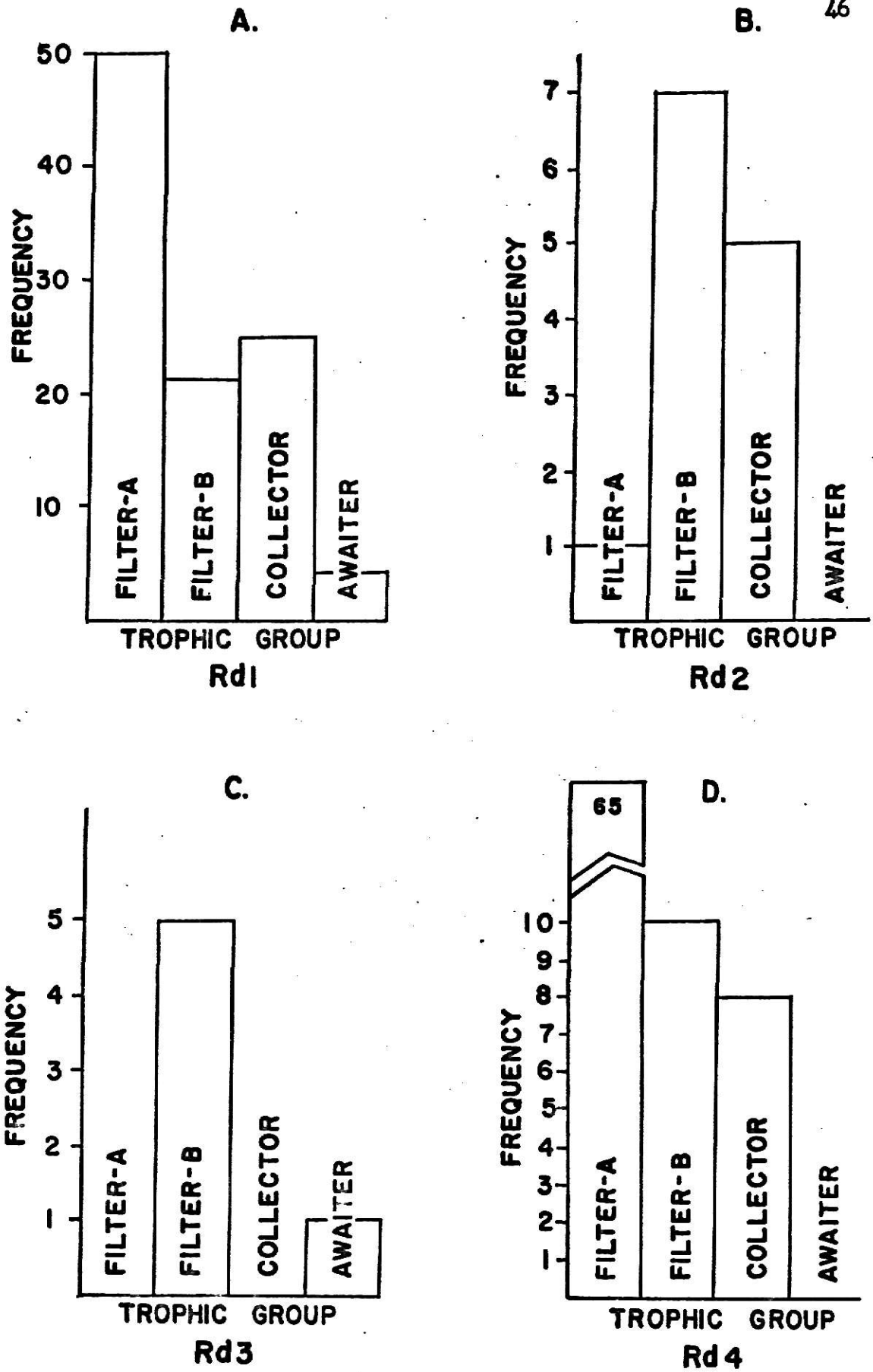


Fig. 16. Frequency of individuals in each trophic group.

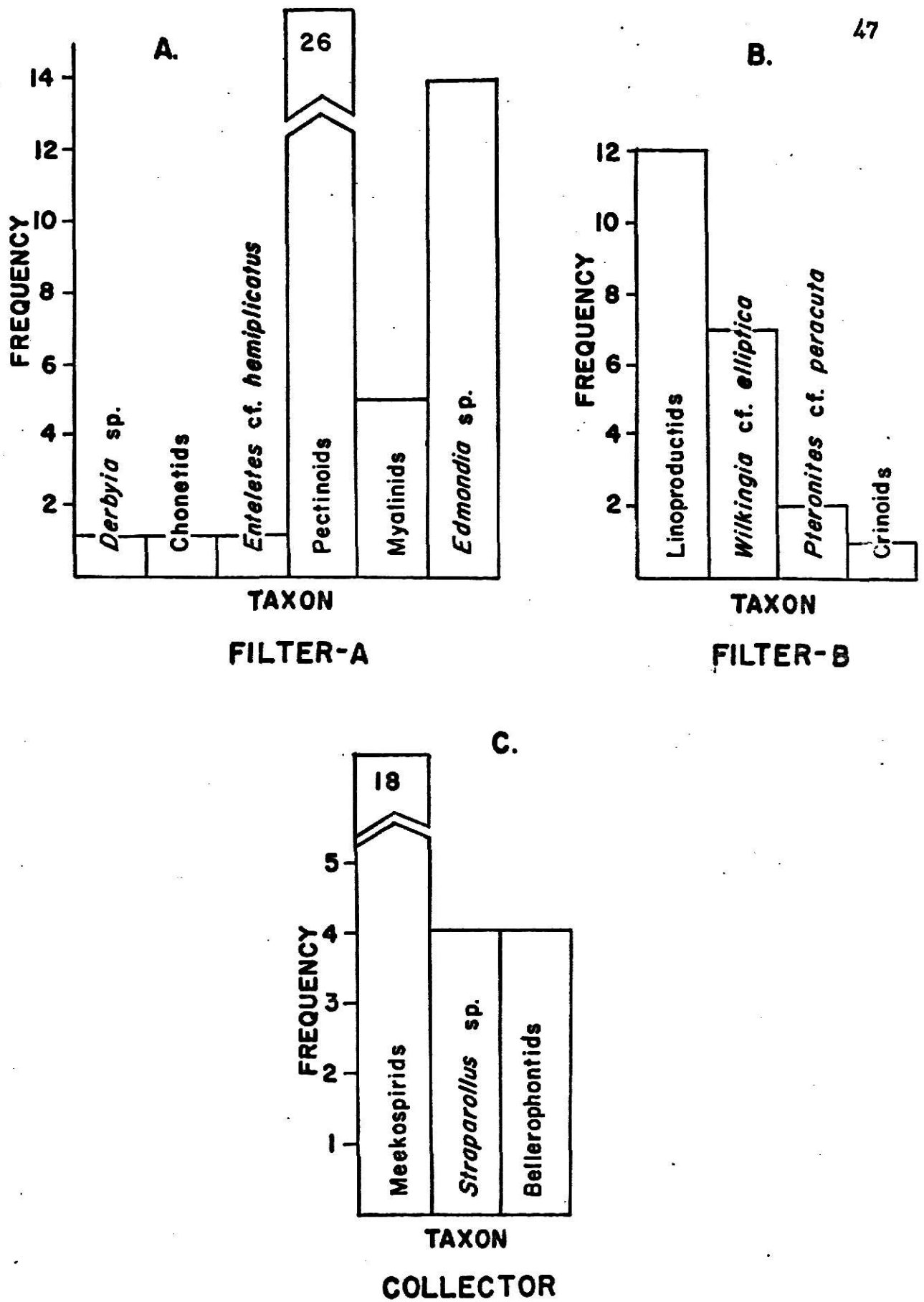


Fig. 17. Number of individuals in each taxon for each trophic group in Horizon Rdl.

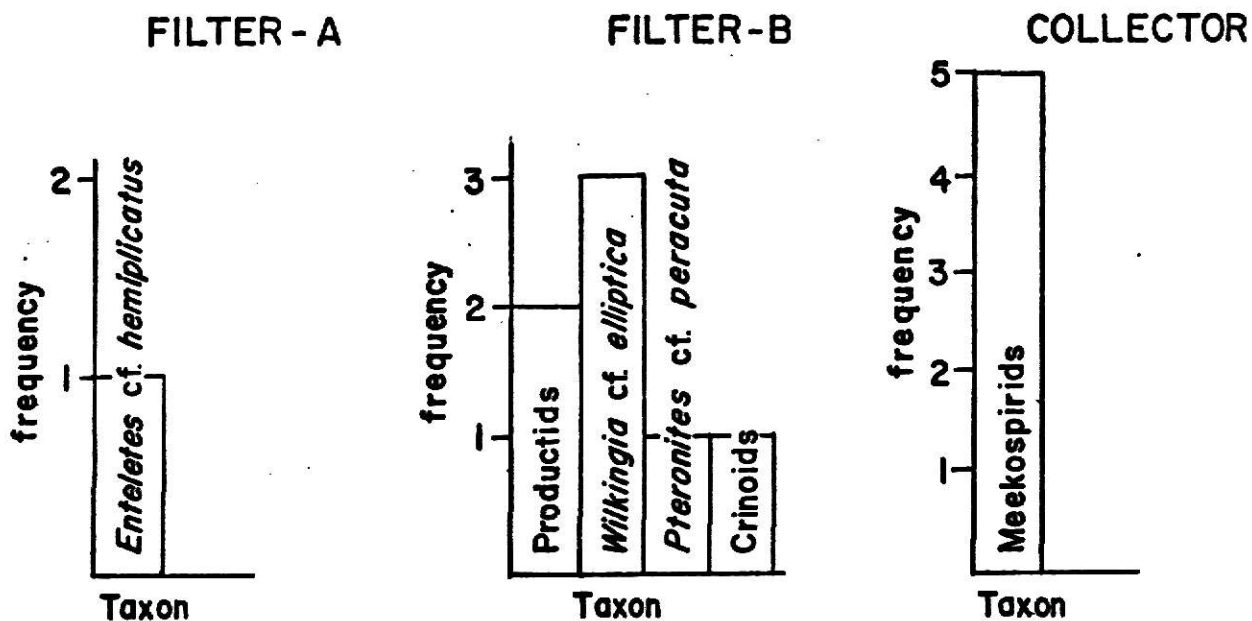


Fig. 18. Number of individuals in each taxon for each trophic group in Horizon Rd2.

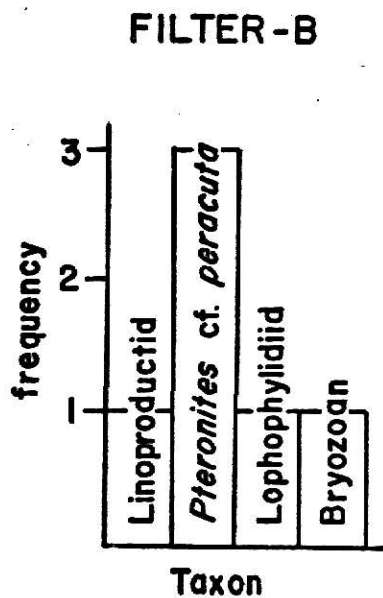


Fig. 19. Number of individuals in each taxon for each trophic group in Horizon Rd3.

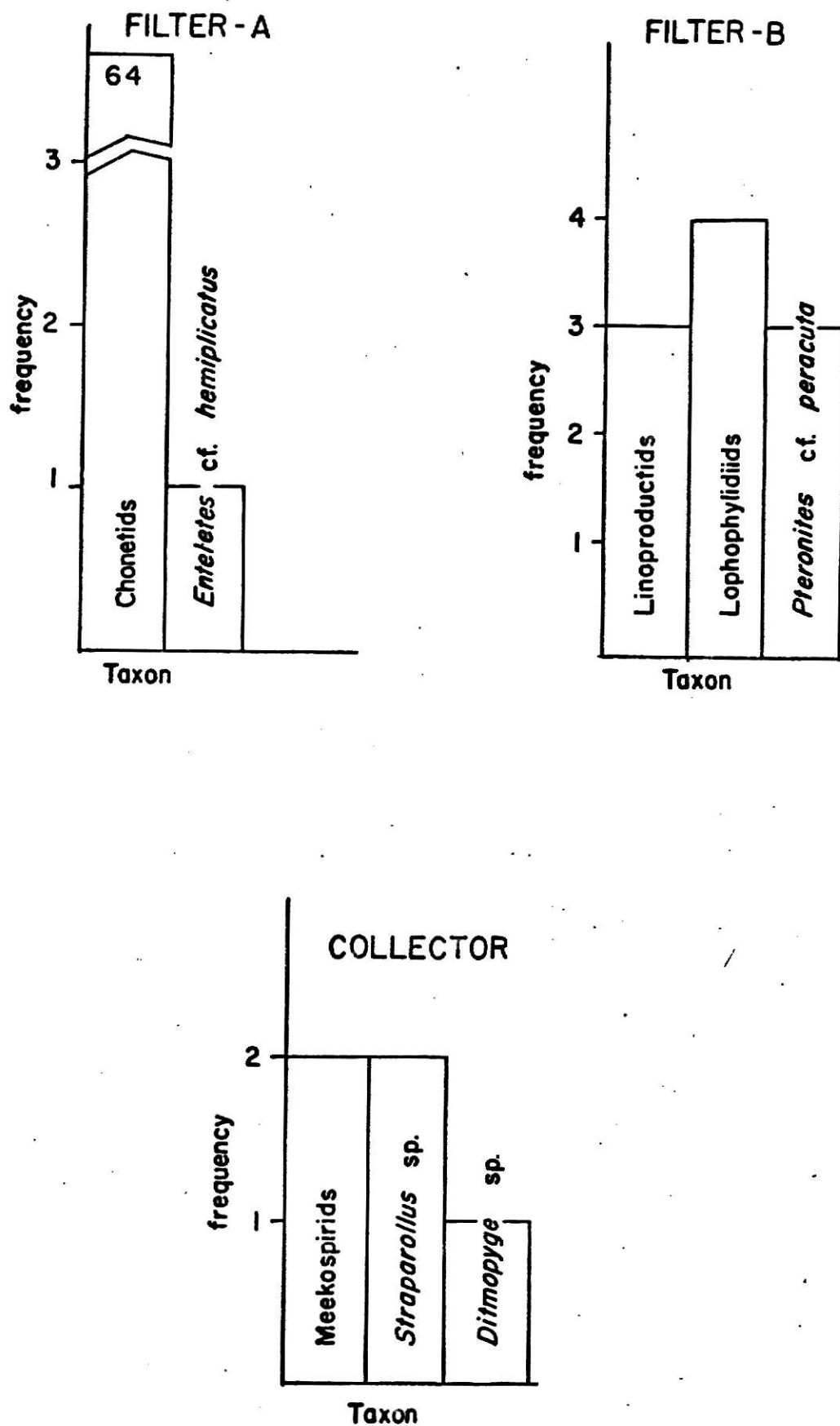


Fig. 20. Number of individuals in each taxon for each trophic group in Horizon Rd4.

meekospirids of the Collector group second (fig. 17). Meekospirids of the Collector group are dominant with Wilkingia cf. elliptica, Filter-B feeders, second on horizon Rd2 (fig. 18). An exception is horizon Rd3 where all are Filter-B feeders (fig. 19). This is probably a result of bias due to small numbers of individuals per square meter on this horizon. Chonetids, Filter-A feeders, are most abundant with lophophylidiids, Filter-B, next (fig. 20) on horizon Rd4.

Turpaeva also found that of a number of taxa belonging to one trophic group, a single taxon commonly dominates the group. One will notice in Figures 17-20 that each trophic group is dominated by a single taxon except for the Collector group in Rd4 (fig. 20). One must remember that we are dealing with a fossil assemblage and several bias factors enter the picture to produce exceptions. Some bias factors are (1) collecting errors, (2) transportation and breakage effects, (3) diagenetic effects, (4) selective predation and (5) selective preservation.

There were no Swallowers in this study. Swallowers are usually represented by soft-bodied organisms with no preservable hard parts and could explain why none are in this fossil assemblage. They are certain to have existed but no detected traces remain.

SUMMARY (CONCLUSIONS)

- (1) Specimens of Wilkingia cf. elliptica and Pteronites cf. peracuta are preserved in inferred life position.

- (2) Some specimens of Echinaria cf. moorei are preserved in inferred life position.
- (3) Correlation between diversity of organisms and insoluble residues in these beds is negative indicating that as the environment stabilized diversity increased.
- (4) Density of organisms (number of individuals per square meter) is higher in beds Rd1 and Rd4 indicating a possible gap in deposition at these two respective times.
- (5) Transportation had little, if any, effect on these assemblages.
- (6) Fossil compass orientation is random.
- (7) There are some differences in allochem grain size of rock within and surrounding skeletons.
- (8) There are no significant differences in the mineralogy of the four beds or major differences of mineralogy within and surrounding the skeletons.
- (9) Trophic structure of assemblages containing Wilkingia cf. elliptica, Pteronites cf. peracuta, Echinaria cf. moorei and their associated organisms yield patterns similar to those found in modern marine benthic communities.

In conclusion, these four beds represent a depositional cycle that began with an unstable environment at the base (Rd1) as reflected by low diversity and high insolubles. Conditions became more stable as reflected by higher diversity and lower insolubles (Rd2 and Rd3). Conditions then returned to an

unstable environment resulting in higher insolubles and lower diversity (Rd4).

Compass orientation of fossils indicate random distribution. Transportation had little effect implying that the assemblages are "in situ". Mineral composition of the substrate was nearly uniform, but major differences in fossil composition were common.

ACKNOWLEDGMENTS

This study was supervised by Dr. R. R. West, whose constant advice and assistance is gratefully acknowledged. I gratefully acknowledge Dr. C. C. Smith, Dr. C. W. Shenkel, Jr., and Dr. P. C. Twiss for critically reviewing the manuscript. I also wish to thank J. A. Jeppesen, M. J. Lee, K. A. Shewell, and R. S. Sawin for providing able assistance in the field; T. C. Bell and C. L. Urish aided in preparing the illustrations. Partial support was afforded by the donors of the Petroleum Research Fund, administered by the American Chemical Society in the form of PRF Grant No. 2077-G3 to Dr. R. R. West. For this support I am grateful. Finally, I wish to express my gratitude to my wife Tranne for field assistance and encouragement throughout the study.

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INTRODUCTION TO APPENDICES

Appendices I-III contain data on beds Rd1 through Rd4 that were obtained by analyses of one inch by two inch thin sections. A rectangle covering as much of the rock as possible was inked on the slides. The average area covered was 5 square centimeters. Click stops on a mechanical stage of the microscope were used so that approximately 1,200 points in each rectangle were counted. Fourteen thin sections were studied. Appendix IV is a Chi-square test of articulation data on horizon Rd1. Appendices V-VIII are maps for each bed of the spatial distribution of megafossils in randomly selected square meters. The abbreviations used on these maps are:

Pt = <u>Pteronites</u> cf. <u>peracuta</u>	S = <u>Straparollus</u> sp.
C = Crinoids	En = <u>Enteleles</u> cf. <u>hemiplicatus</u>
Pr = Productids	W = <u>Wilkingia</u> cf. <u>elliptica</u>
M = Meekospirids	Ch = Chonetid (valve indistinguishable)
E = <u>Edmondia</u> sp.	Chb = Chonetid brachial valve
Ec = <u>Echinaria</u> cf. <u>moorei</u>	Chp = Chonetid pedicle valve
B = Bryozoans	T = <u>Ditmopyge</u> sp.
# Fenestrate	Pe = Pectinoids
 Ramose	Be = Bellerophontids
L = Lophophylidiids	My = Myalinids
D = <u>Derbyia</u> sp.	Ceph = Cephalopod

Appendices IX-XII are Rayleigh's test of randomness for fossils from each horizon. Raleigh's test statistic, z , is $z = \sqrt{V^2} = W^2 / N$, where

$$V = \sum_{i=1}^N \cos \alpha_i, \quad W = \sum_{i=1}^N \sin \alpha_i, \quad (i = 1, 2, 3, \dots, N). \quad \text{is the angle}$$

measured and N is the total number of angles measured.

Appendix I

Thin Section Data for Rock Within and Surrounding Wilkingia cf. elliptica.

Horizon Rd1

Matrix Surrounding Internal Mold

Rock Name Biomicrite

Orthochems - 88.9 percent of Rock

<u>Mineral</u>	<u>Percentage</u>
Micrite	77.76
Spar	3.49
Microspar	13.42
Chert	0.74
Limonite	1.10

Allochems - 11.1 percent of Rock

<u>Fossil</u>	<u>Percentage</u>
Opthalmids	1.47
Bryozoans	17.65
Brachiopods	8.09
Gastropods	13.23
Bivalves	14.71
Ostracodes	11.76
Crinoids	33.09

Allochem mean grain size = 0.43 mm.

Recrystallization - 14.22 percent of Rock

<u>Mode of Occurrence</u>	<u>Percentage</u>
Microspar	83.91
Spar	16.09

Horizon Rd1

Rock Composing Internal Mold

Rock Name Ostracodal Micrite

Orthochems - 96.5 percent of Rock

<u>Mineral</u>	<u>Percentage</u>
Micrite	89.49
Spar	1.42
Microspar	7.89
Chert	0.40
Limonite	0.80

Allochems - 3.5 percent of Rock

<u>Fossil</u>	<u>Percentage</u>
Opthalmids	11.11
Bryozoans	13.89
Brachiopids	2.78
Gastropods	2.77
Bivalves	8.33
Trilobites	2.78
Ostracodes	52.78
Crinoids	5.56

Allochem mean grain size = 0.19 mm.

Largest allochem in mold = 1.0 mm. in diameter

Recrystallization - 8.98 percent of Rock

<u>Mode of Occurrence</u>	<u>Percentage</u>
Microspar	84.78
Spar	15.22

Horizon Rd2

Matrix Surrounding Internal Mold

Rock Name Biomicrite

Orthochems - 86.6 percent of Rock

<u>Mineral</u>	<u>Percentage</u>
Micrite	92.14
Spar	1.92
Microspar	5.94

Allochems - 13.4 percent of Rock

<u>Fossil</u>	<u>Percentage</u>
Ammovertellids	0.50
Opthalmids	2.94
Bryozoans	17.06
Brachiopods	17.06
Gastropods	4.79
Bivalves	22.35
Ostracodes	10.59
Crinoids	21.18
<u>Osagia sp.</u>	3.53

Allochem mean grain size = 0.77 mm.

Recrystallization - 6.80 percent of Rock

<u>Mode of Occurrence</u>	<u>Percentage</u>
Microspar	75.58
Spar	24.42

Horizon Rd2

Rock Composing Internal Mold

Rock Name Bivalve-Brachiopod Micrite

Orthochems - 90.22 percent of Rock

<u>Mineral</u>	<u>Percentage</u>
Micrite	96.40
Spar	0.01
Microspar	3.59
Chert	trace
Limonite	trace

Allochems - 9.78 percent of Rock

<u>Fossil</u>	<u>Percentage</u>
Opthalmids	4.62
Bryozoans	11.54
Brachiopods	21.54
Gastropods	3.85
Bivalves	31.54
Ostracodes	6.15
Crinoids	8.46
<u>Osagia sp.</u>	12.31

Allochem mean grain size = 0.58 mm.

Largest allochem in internal mold = 0.7 mm by 4.0 mm.

Recrystallization - 3.69 percent of Rock

<u>Mode of Occurrence</u>	<u>Percentage</u>
Microspar	87.76
Spar	12.24

Horizon Rd4

Matrix Surrounding Internal Mold

Rock Name Biomicrite

Orthochems - 81.9 percent of Rock

<u>Mineral</u>	<u>Percentage</u>
Micrite	78.11
Spar	4.02
Microspar	14.24
Chert	trace
Limonite	3.63
Pyrite	trace

Allochems - 18.1 percent of Rock

<u>Fossil</u>	<u>Percentage</u>
Paleotextularids	1.30
<u>Endothyra</u> sp.	0.87
<u>Opthalmids</u>	14.29
Bryozoans	17.32
Brachiopods	10.39
Gastropods	6.49
Bivalves	5.19
Ostracodes	13.42
Crinoids	22.94
<u>Osagia</u> sp.	7.79

Allochem mean grain size = 0.46 mm.

Recrystallization - 14.96 percent of Rock

<u>Mode of Occurrence</u>	<u>Percentage</u>
Microspar	78.09
Spar	21.91

Horizon Rd4

Rock Composing Internal Mold

Rock Name Biomicrite

Orthochems - 79.6 percent of Rock

<u>Mineral</u>	<u>Percentage</u>
Micrite	79.39
Spar	4.18
Microspar	16.43
Chert	trace
Limonite	trace

Allochems - 20.4 percent of Rock

<u>Fossil</u>	<u>Percentage</u>
Ammovertellids	0.80
Paleotextularids	1.59
Ophalmids	7.97
Bryozoans	11.95
Brachiopods	18.73
Gastropods	1.99
Bivalves	17.13
Ostracodes	9.16
Crinoids	22.31
<u>Osagia</u> sp.	8.37

Allochem mean grain size = 0.73 mm.

Largest allochem in internal mold = 2.5 mm by 1.7 mm.

Recrystallization - 16.41 percent of Rock

<u>Mode of Occurrence</u>	<u>Percentage</u>
Microspar	80.50
Spar	19.50

Appendix II

Thin Section Data for Rock Within and Surrounding Pteronites cf. peracuta

Horizon Rd3

Matrix Surrounding Shell

Rock Name Biomicrite

Orthochems - 86.3 percent of Rock

<u>Mineral</u>	<u>Percentage</u>
Micrite	85.20
Spar	2.98
Microspar	11.82
Limonite	trace

Allochems - 13.7 percent of Rock

<u>Fossil</u>	<u>Percentage</u>
Opthalmids	3.47
Bryozoans	23.61
Brachiopods	9.03
Gastropods	9.02
Bivalves	24.31
Trilobites	0.70
Ostracodes	6.25
Crinoids	9.03
<u>Osagia</u> sp.	14.58

Allochem mean grain size = 0.64 mm.

Recrystallization - 12.77 percent of Rock

<u>Mode of Occurrence</u>	<u>Percentage</u>
Microspar	70.85
Spar	20.15

Horizon Rd3

Rock within Shell

Rock Name Biomicrudite

Orthochems - 85.1 percent of Rock

<u>Mineral</u>	<u>Percentage</u>
Micrite	85.01
Spar	2.84
Microspar	11.65
Chert	0.50

Allochems - 14.9 percent of Rock

<u>Fossil</u>	<u>Percentage</u>
Opthalmids	0.52
Bryozoans	0.52
Brachiopods	2.09
Gastropods	8.38
Bivalves	79.07
Ostracodes	0.52
Crinoids	0.52
<u>Osagia sp.</u>	8.38

Allochem mean grain size = 1.53 mm.

Recrystallization - 12.33 percent of Rock

<u>Mode of Occurrence</u>	<u>Percentage</u>
Microspar	80.38
Spar	19.62

Horizon Rd4

Matrix Surrounding Shell

Rock Name Biomicrite

Orthochems - 76.4 percent of Rock

<u>Mineral</u>	<u>Percentage</u>
Micrite	82.78
Spar	3.77
Microspar	11.56
Limonite	1.26
Pyrite	0.63

Allochems - 23.61 percent of Rock

<u>Fossil</u>	<u>Percentage</u>
Paleotextularids	0.41
Ophthalmids	5.69
Bryozoans	5.69
Brachiopods	17.89
Gastropods	9.75
Bivalves	21.95
Trilobites	2.85
Ostracodes	9.75
Crinoids	16.26
<u>Osagia</u> sp.	9.76

Allochem mean grain size = 0.96 mm.

Recrystallization - 11.71 percent of Rock

<u>Mode of Occurrence</u>	<u>Percentage</u>
Microspar	75.41
Spar	24.59

Horizon Rd4

Rock within Shell

Rock Name Fossiliferous Micrite

Orthochems - 91.8 percent of Rock

<u>Mineral</u>	<u>Percentage</u>
Micrite	85.84
Spar	3.08
Microspar	9.73
Chert	0.29
Limonite	0.19
Pyrite	0.87

Allochems - 8.22 percent of Rock

<u>Fossil</u>	<u>Percentage</u>
<u>Endothyra</u> sp.	3.23
Opthalmids	21.51
Bryozoans	7.53
Brachiopods	2.15
Gastropods	2.15
Bivalves	5.37
Ostracodes	9.68
Crinoids	33.33
<u>Osagia</u> sp.	15.05

Allochem mean grain size = 0.59 mm.

Recrystallization - 11.76 percent of Rock

<u>Mode of Occurrence</u>	<u>Percentage</u>
Microspar	75.94
Spar	24.06

Appendix III

Thin Section Data for Rock Within and Surrounding Echinaria cf. moorei

Horizon Rd2

Matrix Surrounding Shell

Rock Name Biomicrite

Orthochems - 85.6 percent of Rock

<u>Mineral</u>	<u>Percentage</u>
Micrite	94.16
Spar	0.57
Microspar	4.89
Limonite	0.38

Allochems - 14.4 percent of Rock

<u>Fossil</u>	<u>Percentage</u>
Opthalmids	1.71
Paleotextularids	0.57
Ammovertellids	0.57
Bryozoans	6.86
Brachiopods	14.29
Gastropods	3.43
Bivalves	26.86
Trilobites	0.57
Ostracodes	4.00
Crinoids	33.71
<u>Osagia</u> sp.	7.43

Allochem mean grain size = 0.97 mm.

Recrystallization - 4.68 percent of Rock

<u>Mode of Occurrence</u>	<u>Percentage</u>
Microspar	89.47
Spar	10.53

Horizon Rd2

Rock within Shell

Rock Name Fossiliferous Micrite

Orthochems - 97.8 percent of Rock

<u>Mineral</u>	<u>Percentage</u>
Micrite	97.87
Microspar	2.13

Allochems - 2.2 percent of Rock

<u>Fossil</u>	<u>Percentage</u>
Opthalmids	14.29
Gastropods	57.14
Bivalves	17.86
Ostracodes	10.71

Allochem mean grain size = 0.41 mm.

Largest allochem in shell = 1.6 mm by 0.8 mm.

Recrystallization - 2.08 percent of Rock

<u>Mode of Occurrence</u>	<u>Percentage</u>
Microspar	100.0

Horizon Rd4

Matrix Surrounding Shell

Rock Name Biomicrudite

Orthochems - 73.2 percent of Rock

<u>Mineral</u>	<u>Percentage</u>
Micrite	81.96
Spar	4.31
Microspar	13.73

Allochems - 26.8 percent of Rock

<u>Fossil</u>	<u>Percentage</u>
Bryozoans	36.40
Brachiopods	10.29
Gastropods	3.68
Bivalves	18.00
Ostracodes	0.74
Crinoids	25.74
<u>Osagia</u> sp.	5.15

Allochem mean grain size = 1.10 mm.

Recrystallization - 13.2 percent of Rock

<u>Mode of Occurrence</u>	<u>Percentage</u>
Microspar	76.12
Spar	23.88

Horizon Rd4

Rock within Shell

Rock Name Biomicrudite

Orthochems - 80.6 percent of Rock

<u>Mineral</u>	<u>Percentage</u>
Micrite	97.09
Spar	2.58
Chert	0.22
Limonite	0.11

Allochems - 19.4 percent of Rock

<u>Fossil</u>	<u>Percentage</u>
Paleotextularids	0.47
Ophalmids	1.40
Bryozoans	21.03
Brachiopods	5.61
Gastropods	5.61
Bivalves	21.96
Ostracodes	2.80
Crinoids	31.31
<u>Osagia sp.</u>	9.81

Allochem mean grain size = 1.09 mm.

Recrystallization - 11.5 percent of Rock

<u>Mode of Occurrence</u>	<u>Percentage</u>
Microspar	81.89
Spar	18.11

Appendix IV

Chi-square Test for Articulation Data on Horizon Rd1

Edmondia sp.

<u>No. of Left Valves</u>	
<u>Observed</u>	<u>Expected</u>

6

5.5

<u>No. of Right Valves</u>	
<u>Observed</u>	<u>Expected</u>

5

5.5

$$\chi^2 = \frac{(\text{observed} - \text{expected})^2}{\text{expected}} = \frac{(6 - 5.5)^2}{5.5} + \frac{(5 - 5.5)^2}{5.5}$$

$\chi^2 = 0.09$ which is not significant at the .05 level with one degree of freedom (a value of 3.84 or more would be needed here to show significant difference).

Myalinid

<u>No. of Left Valves</u>	
<u>Observed</u>	<u>Expected</u>

4

6

<u>No. of Right Valves</u>	
<u>Observed</u>	<u>Expected</u>

8

6

$$\chi^2 = \frac{(\text{observed} - \text{expected})^2}{\text{expected}} = \frac{(4 - 6)^2}{6} + \frac{(8 - 6)^2}{6}$$

$\chi^2 = 1.32$ which is not significant at the .05 level with one degree of freedom (a value of 3.84 or more would be needed here to show significant difference).

Appendix IX

Test of Randomness of Fossil Orientation on Horizon Rdl

Linoproductids			
Mid Point of Class (degrees)	Number of ind. in Class (n)	$n \times \sin \alpha_i$	$n \times \cos \alpha_i$
15	7	1.812	6.762
45	8	5.657	5.657
75	5	4.830	1.294
105	0		
135	4	2.779	-2.877
165	1	0.242	-0.970
195	3	-0.776	-2.898
225	3	-2.121	-2.121
255	2	-1.932	-0.518
285	2	-1.923	0.551
315	3	-2.084	2.158
345	2	-0.484	1.815
N = 40		$\sum_{i=1}^N (\sin \alpha_i)^2 = 5.999$	$\sum_{i=1}^N (\cos \alpha_i)^2 = 8.853$

$$z = \frac{5.999 - 8.853}{40} = 2.859^*$$

P .05	P .01
2.996	4.605

*Not significant.

Wilkingia cf. elliptica

Mid Point of Class (degrees)	Number of ind. in Class (n)	$n \times \sin \alpha_i$	$n \times \cos \alpha_i$
15	2	0.518	1.932
45	2	1.414	1.414
75	1	0.966	0.259
105	1	0.966	-0.259
135	1	0.707	-0.707
165	0		
195	0		
225	0		
255	0		
285	1	-0.966	0.259
315	2	-1.414	1.414
345	0		
N = 10	$\sum_{i=1}^N \sin \alpha_i^2 =$	4.800	$\sum_{i=1}^N \cos \alpha_i^2 =$ 18.593

$$z = \frac{4.800 + 18.593}{10} = 2.339^*$$

P .05	P .01
2.919	4.290

*Not significant.

Appendix X

Test of Randomness of Fossil Orientation on Horizon Rd2

Echinara cf. moorei

Mid Point of Class (degrees)	Number of ind. in Class (n)	$n \times \sin \alpha_i$	$n \times \cos \alpha_i$
15	3	0.776	2.898
45	3	2.121	2.121
75	6	5.796	1.553
105	4	3.864	-1.035
135	5	3.536	-3.536
165	5	1.294	-4.830
195	3	-0.776	-2.898
225	6	-4.243	-4.243
255	5	-1.932	-0.518
285	2	-0.776	2.898
315	4	-2.828	2.828
345	4	-1.035	3.864
N = 47		$\sum_{i=1}^N (\sin \alpha_i)^2 = 43.190$	$\sum_{i=1}^N (\cos \alpha_i)^2 = 7.618$

$$z = \frac{43.190 + 7.618}{47} = 1.016*$$

P .05	P .01
2.996	4.605

*Not significant.

Enteleles cf. hemiplicatus

Mid Point of Class (degrees)	Number of ind. in Class (n)	$n \times \sin \alpha_i$	$n \times \cos \alpha_i$
15	2	0.518	1.932
45	1	0.707	0.707
75	0		
105	2	1.932	-0.518
135	3	2.121	-2.121
165	1	0.259	-0.966
195	2	-0.518	-1.932
225	1	-0.707	-0.707
255	0		
285	2	-1.932	0.518
315	0		
345	0		
N = 14		$\left(\sum_{i=1}^N \sin \alpha_i \right)^2 = 5.664$	$\left(\sum_{i=1}^N \cos \alpha_i \right)^2 = 9.529$

$$z = \frac{5.664 + 9.529}{14} = 1.085*$$

P .05	P .01
2.941	4.383

*Not significant.

Crinoids

Mid Point of Class (degrees)	Number of ind. in Class (n)	$n \times \sin \alpha_i$	$n \times \cos \alpha_i$
15	6	1.553	5.796
45	5	3.536	3.536
75	6	5.796	1.553
105	8	7.727	-2.071
135	4	2.828	-2.828
165	3	0.776	-2.898
195	6	-1.553	-5.796
225	5	-3.536	-3.536
255	6	-5.796	-1.553
285	8	-7.727	2.071
315	4	-2.828	2.828
345	3	-0.776	2.898
N = 29		$\sum_{i=1}^N (\sin \alpha_i)^2 = 0.000$	$\sum_{i=1}^N (\cos \alpha_i)^2 = 0.000$

$$z = \frac{0}{29} = 0^*$$

$\frac{P .05}{2.996}$	$\frac{P .01}{4.605}$
-----------------------	-----------------------

*Not significant.

Wilkingia cf. elliptica

Mid Point of Class (degrees)	Number of Ind. in (Class (n))	$n \times \sin \alpha_i$	$n \times \cos \alpha_i$
15	9	2.329	8.693
45	3	2.121	2.121
75	1	0.966	0.259
105	2	1.932	-0.518
135	4	2.828	-2.828
165	2	0.518	-1.932
195	2	-0.518	-1.932
225	4	-2.828	-2.828
255	3	-2.898	-0.776
285	2	-1.932	0.518
315	2	-1.414	1.414
345	2	-0.518	1.932

$$N = 36 \quad \left(\sum_{i=1}^N \sin \alpha_i \right)^2 = 0.586 \quad \left(\sum_{i=1}^N \cos \alpha_i \right)^2 = 4.123$$

$$z = \frac{0.586 + 4.123}{36} = 0.481*$$

P .05	P .01
2.996	4.605

*Not significant.

Pteronites cf. peracuta

Mid Point of Class (degrees)	Number of ind. in Class (n)	$n \times \sin \alpha_i$	$n \times \cos \alpha_i$
15	4	1.035	3.864
45	1	0.707	0.707
75	1	0.966	0.259
105	2	1.932	-0.518
135	0		
165	1	0.259	-0.966
195	3	-0.776	-2.898
225	3	-2.121	-2.121
255	0		
285	2	-1.932	0.518
315	0		
345	2	-0.518	1.932
N = 19		$\sum_{i=1}^N (\sin \alpha_i)^2 = 0.201$	$\sum_{i=1}^N (\cos \alpha_i)^2 = 0.604$

$$z = \frac{0.201 + 0.604}{19} = 0.040^*$$

P .05	P .01
2.956	4.443

*Not significant.

Appendix XI

Test of Randomness of Fossil Orientation on Horizon Rd3

Pteronites cf. peracuta

Mid Point of Class (degrees)	Number of ind. in Class (n)	$n \times \sin \alpha_i$	$n \times \cos \alpha_i$
15	1	0.259	0.966
45	2	1.414	1.414
75	0		
105	6	5.796	-1.553
135	1	0.707	-0.707
165	0		
195	4	-1.035	-3.864
225	4	-2.828	-2.828
255	1	-0.966	-0.259
285	3	-2.898	0.776
315	2	-1.141	1.141
345	1	-0.259	0.966
N = 25		$(\sum_{i=1}^N \sin \alpha_i)^2 = 1.498$	$(\sum_{i=1}^N \cos \alpha_i)^2 = 13.506$

$$z = \frac{1.498 + 13.506}{25} = 0.598*$$

P .05	P .01
2.996	4.605

*Not significant.

Wilkingia cf. elliptica

Mid Point of Class (degrees)	Number of ind. in Class (n)	$n \times \sin \alpha_i$	$n \times \cos \alpha_i$
15	1	0.259	0.966
45	1	0.707	0.707
75	2	1.932	0.518
105	0		
135	0		
165	0		
195	2	-0.518	-1.932
225	1	-0.707	-0.707
255	1	-0.966	-0.259
285	1	-0.966	-0.259
315	0		
345	0		
N = 9		$(\sum_{i=1}^N \sin \alpha_i)^2 = 0.067$	$(\sum_{i=1}^N \cos \alpha_i)^2 = 0.200$

$$z = \frac{0.067 + 0.200}{9} = 0.030^*$$

P .05	P .01
2.910	4.250

*Not significant.

Appendix XII

Test of Randomness of Fossil Orientation on Horizon Rd4

Echinaria cf. moorei

Mid Point of Class (degrees)	Number of ind. in Class (n)	$n \times \sin \alpha_i$	$n \times \cos \alpha_i$
15	2	0.518	1.932
45	2	1.414	1.414
75	1	0.966	0.259
105	0		
135	0		
165	0		
195	1	-0.259	-0.966
225	0		
255	2	-1.932	-0.518
285	1	-0.966	0.259
315	1	-0.707	0.707
345	2	-0.518	1.414
N - 12		$\sum_{i=1}^N (\sin \alpha_i)^2 = 2.202$	$\sum_{i=1}^N (\cos \alpha_i)^2 = 25.190$

$$z = \frac{2.202 + 25.190}{12} = 2.280*$$

P .05	P .01
2.932	4.344

* Not significant.

Linoproductids

Mid Point of Class (degrees)	Number of ind. in Class (n)	$n \times \sin \alpha_i$	$n \times \cos \alpha_i$
15	1	0.259	0.966
45	2	1.414	1.414
75	4	3.864	1.035
105	0		
135	1	0.707	-0.707
165	1	0.259	-0.966
195	1	-0.259	-0.966
225	1	-0.707	-0.707
255	1	-0.966	-0.259
285	0		
315	2	-1.414	1.414
345	0		
N = 14	$\sum_{i=1}^N \sin \alpha_i$	$\sum_{i=1}^N \sin \alpha_i = 9.967$	$\sum_{i=1}^N \cos \alpha_i = 1.498$

$$z = \frac{9.967 + 1.498}{14} = 0.818*$$

P .05	P .01
2.941	4.383

* Not significant.

Enteleles cf. hemiplicatus

Mid Point of Class (degrees)	Number of ind. in Class (n)	$n \times \sin \alpha_i$	$n \times \cos \alpha_i$
15	2	0.518	1.932
45	4	2.828	2.828
75	2	1.932	0.518
105	1	0.966	-0.259
135	4	2.828	-2.828
165	1	0.259	-0.966
195	2	-0.518	-1.932
225	1	-0.707	-0.707
255	0		
285	2	-1.932	0.518
315	3	-2.121	2.121
345	1	-0.259	0.966
N = 23		$\sum_{i=1}^N \sin \alpha_i)^2 = 14.394$	$\sum_{i=1}^N \cos \alpha_i)^2 = 4.800$

$$z = \frac{14.394 + 4.800}{23} = 0.834 *$$

P .05	P .01
2.963	4.472

* Not significant.

Crinoids

Mid Point of Class (degrees)	Number of ind. in Class (n)	$n \times \sin \alpha_i$	$n \times \cos \alpha_i$
15	50	12.941	48.296
45	54	38.184	38.184
75	47	45.399	12.164
105	38	36.705	-9.835
135	44	31.113	-31.113
165	35	-9.059	-33.807
195	50	-12.941	-48.296
225	54	-38.184	-38.184
255	47	-45.399	-12.164
285	38	-36.705	9.835
315	44	-31.113	31.113
345	35	-9.059	33.807
N = 268		$(\sum_{i=1}^N \sin \alpha_i)^2 = 0.000$	$(\sum_{i=1}^N \cos \alpha_i)^2 = 0.000$

$$z = \frac{0}{268} = 0*$$

P .05	P. .01
2.996	4.605

* Not significant.

Wilkingia cf. elliptica

Mid Point of Class (degrees)	Number of ind. in Class (n)	$n \times \sin \alpha_i$	$n \times \cos \alpha_i$
15	3	0.776	2.898
45	6	4.243	4.243
75	2	1.932	0.518
105	1	0.966	-0.259
135	4	2.828	-2.828
165	1	0.259	-0.966
195	2	-0.518	-1.932
225	4	-2.828	-2.828
255	4	-3.864	-1.035
285	1	-0.966	0.259
315	3	-2.121	2.121
345	5	-1.294	4.830

N = 36

$$\left(\sum_{i=1}^N \sin \alpha_i \right)^2 = 0.345 \quad \left(\sum_{i=1}^N \cos \alpha_i \right)^2 = 25.210$$

$$z = \frac{0.345 + 25.210}{36} = 0.769^*$$

P .05	P .01
2.996	4.605

* Not significant.

Pteronites cf. peracuta

Mid Point of Class (degrees)	Number of ind. in Class (n)	$n \times \sin \alpha_i$	$n \times \cos \alpha_i$
15	5	1.294	4.830
45	3	2.121	2.121
75	4	3.864	1.035
105	3	2.898	-0.776
135	3	2.121	-2.121
165	0		
195	8	-2.070	-7.727
225	3	-2.457	-1.721
255	3	-2.898	-0.776
285	1	-0.966	0.259
315	2	-1.414	1.414
345	3	-0.776	2.898

N = 38

$$\left(\sum_{i=1}^N \sin \alpha_i \right)^2 = 2.948$$

$$\left(\sum_{i=1}^N \cos \alpha_i \right)^2 = 0.318$$

$$z = \frac{2.948 + 0.318}{38} = 0.0850*$$

P .05	P .01
2.996	4.605

* Not significant.

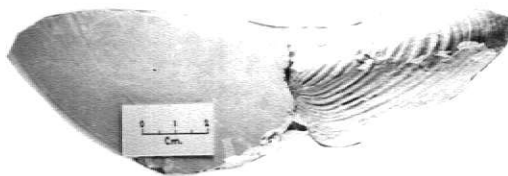
EXPLANATION OF PLATE I

- Fig. 1. Wilkingia cf. elliptica (Horizon Rd1), X1. Right valve exterior.
2. Wilkingia cf. elliptica (Horizon Rd1), X0.5. Left valve exterior
3. Pteronites cf. peracuta (Horizon Rd3), X0.75. Right valve exterior.
4. Pteronites cf. peracuta (Horizon Rd3), X0.7. Right valve exterior in presumed life position (same as figure 3).
5. Echinaria cf. moorei (Winterset Limestone Member of Dennis Limestone Formation, SE cor. sec. 28, T. 20 S., R. 22 E., Linn County, Kansas), X2. Lateral view, pedicle valve.
6. Echinaria cf. moorei (Horizon Rd3), X1. Lateral view, pedicle valve in presumed life position.

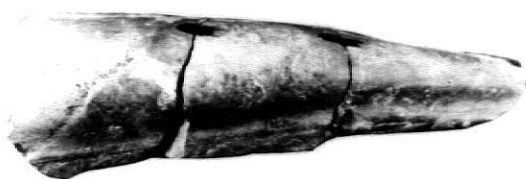
PLATE I



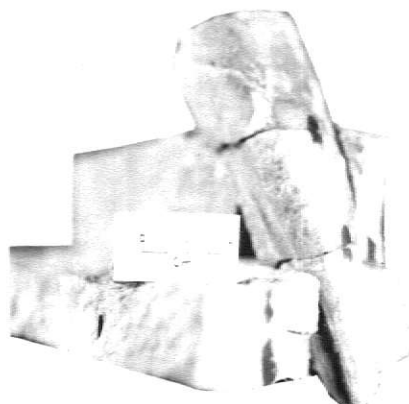
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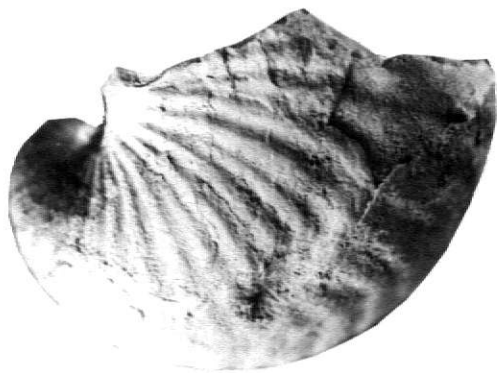
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5



6

PALEOECOLOGY OF SOME UPPER PENNSYLVANIAN
BENTHIC INVERTEBRATES

by

RONALD WAYNE PEARCE

B. S., Kansas State University, 1970

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

1973

ABSTRACT

A paleoecologic study of four bedding planes in the Reading Limestone Member of the Emporia Formation was undertaken to determine (1) preferred compass orientations of megafossils for paleowave and/or paleocurrent determinations, (2) animal-substrate relationships, (3) fossil density and diversity and (4) carbonate petrology of lithology surrounding and filling the "in situ" fossils.

Diversity calculations using both information theory formula and an equitability coefficient were calculated. Diversity is inversely proportional to environmental stability using insoluble residues as an indicator of stability.

Densities of organisms were higher on the upper and lower beds. These are postulated to be the result of gaps in deposition allowing more time for skeletal accumulation.

Lack of breakage, subequal numbers of right and left valves for bivalves and subequal numbers of pedicle and brachial valves for brachiopods are supporting evidence for "in situ" assemblages of organisms in each horizon. Compass orientation of fossils is random.

Thin section analyses revealed no significant differences in petrology of the four limestone beds. There are no major differences in rock within and surrounding the fossils except mean grain size of allochems which are larger in surrounding matrix than in matrix within the fossils.

From petrologic analysis and comparison of fossils with similar modern organisms, the substrate is inferred to have been a soft carbonate

mud containing small percentages (5-20 percent) of shell debris.

Trophic analysis using the method of Turpaeva (1957) reveals that the assemblages follow her patterns very closely. Each horizon has one dominant trophic group, each trophic group has one dominant taxon, and the most abundant taxon belongs to a different trophic group from the second most abundant taxon.

ILLEGIBLE DOCUMENT

**THE FOLLOWING
DOCUMENT(S) IS OF
POOR LEGIBILITY IN
THE ORIGINAL**

**THIS IS THE BEST
COPY AVAILABLE**

OVERSIZED DOCUMENT

**THE FOLLOWING DOCUMENTS ARE BEING
FILMED IN SECTIONS.**

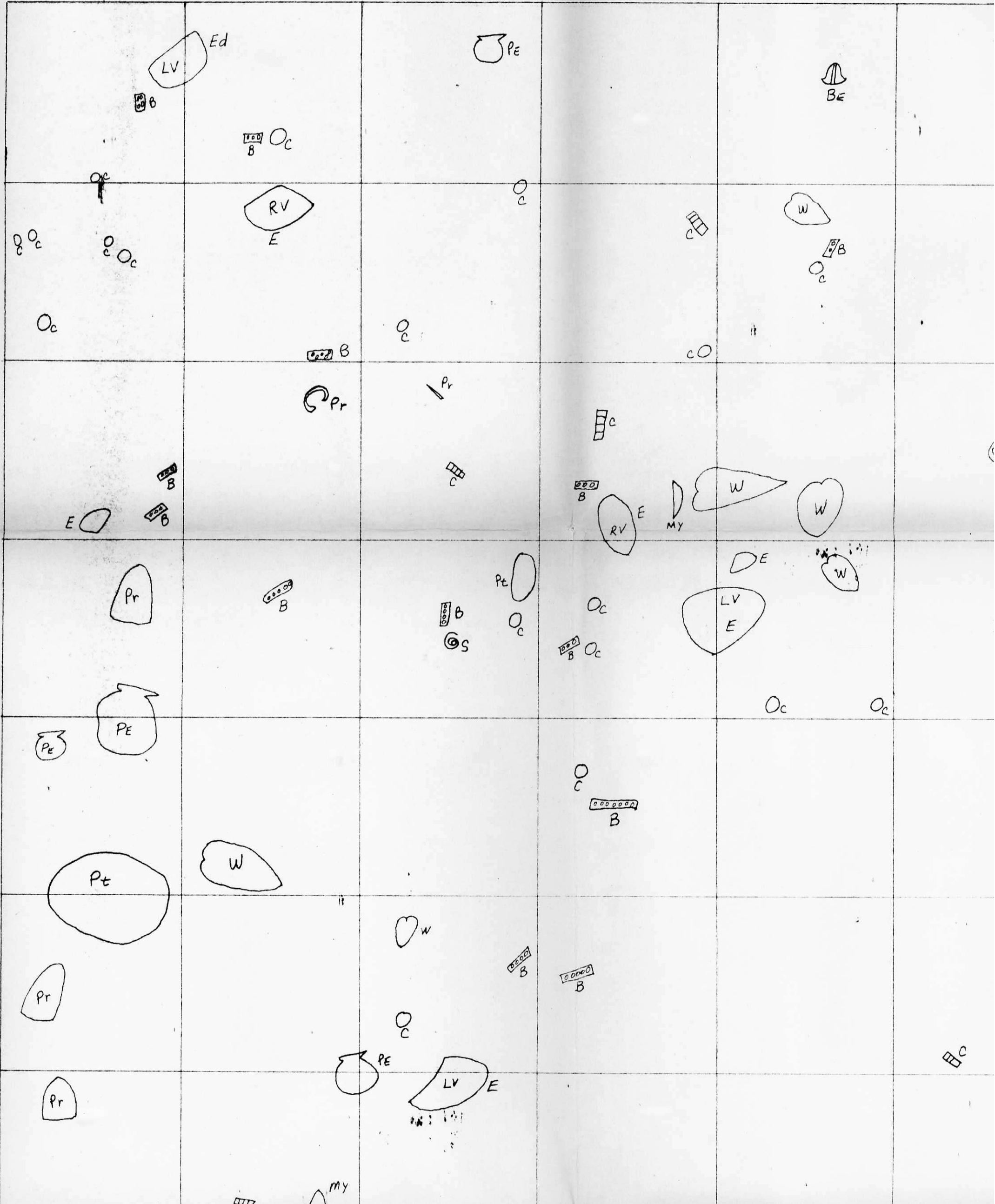
**THE FOLLOWING IMAGES WILL BE TAKEN
FROM LEFT TO RIGHT, TOP TO BOTTOM.
SEE EXAMPLE BELOW:**

1	2	3
4	5	6
7	8	9

SPATIAL DISTRIBUTION OF ORGANISMS IN A SC

SCALE 2 INCHES = 1 DEC

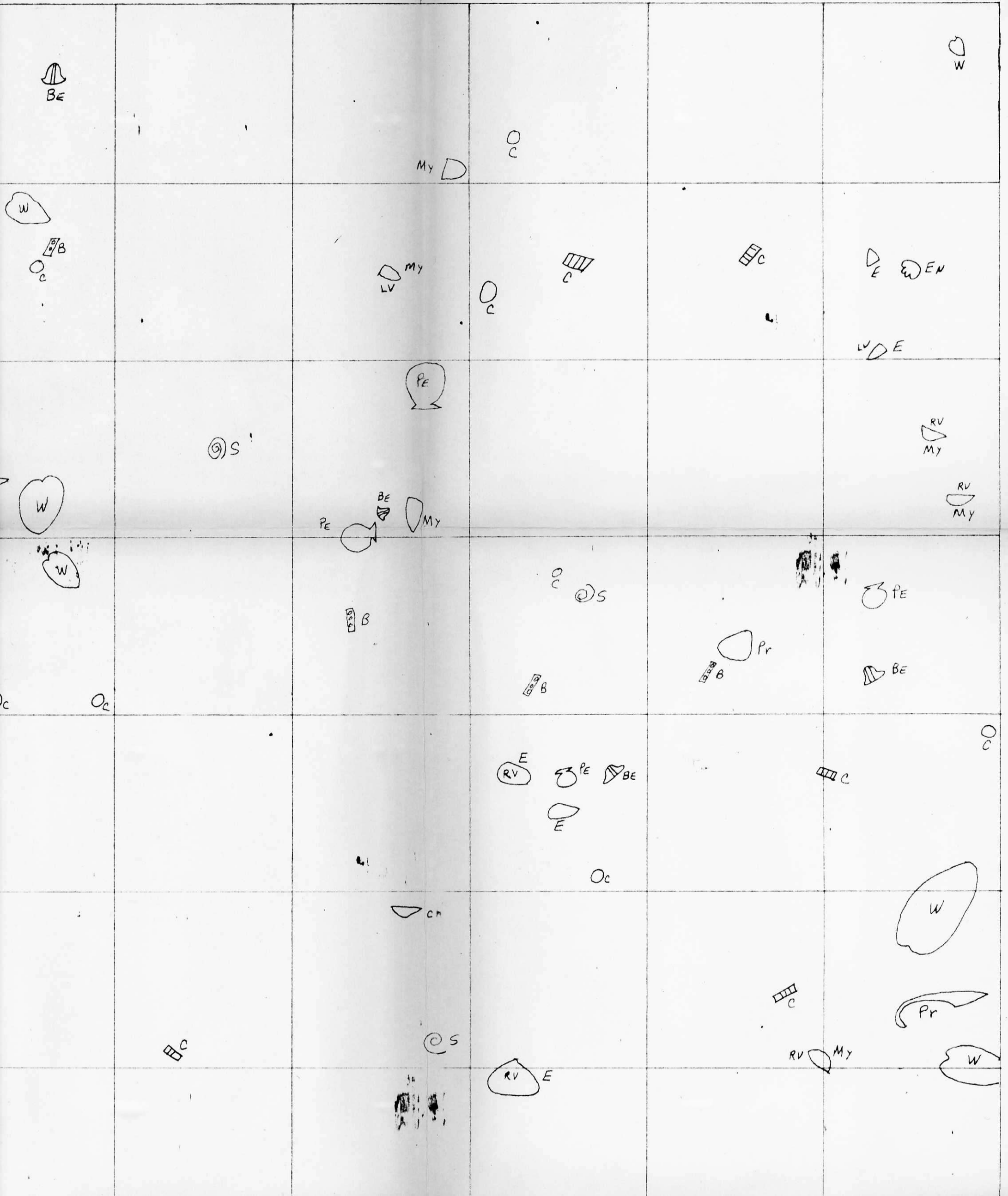
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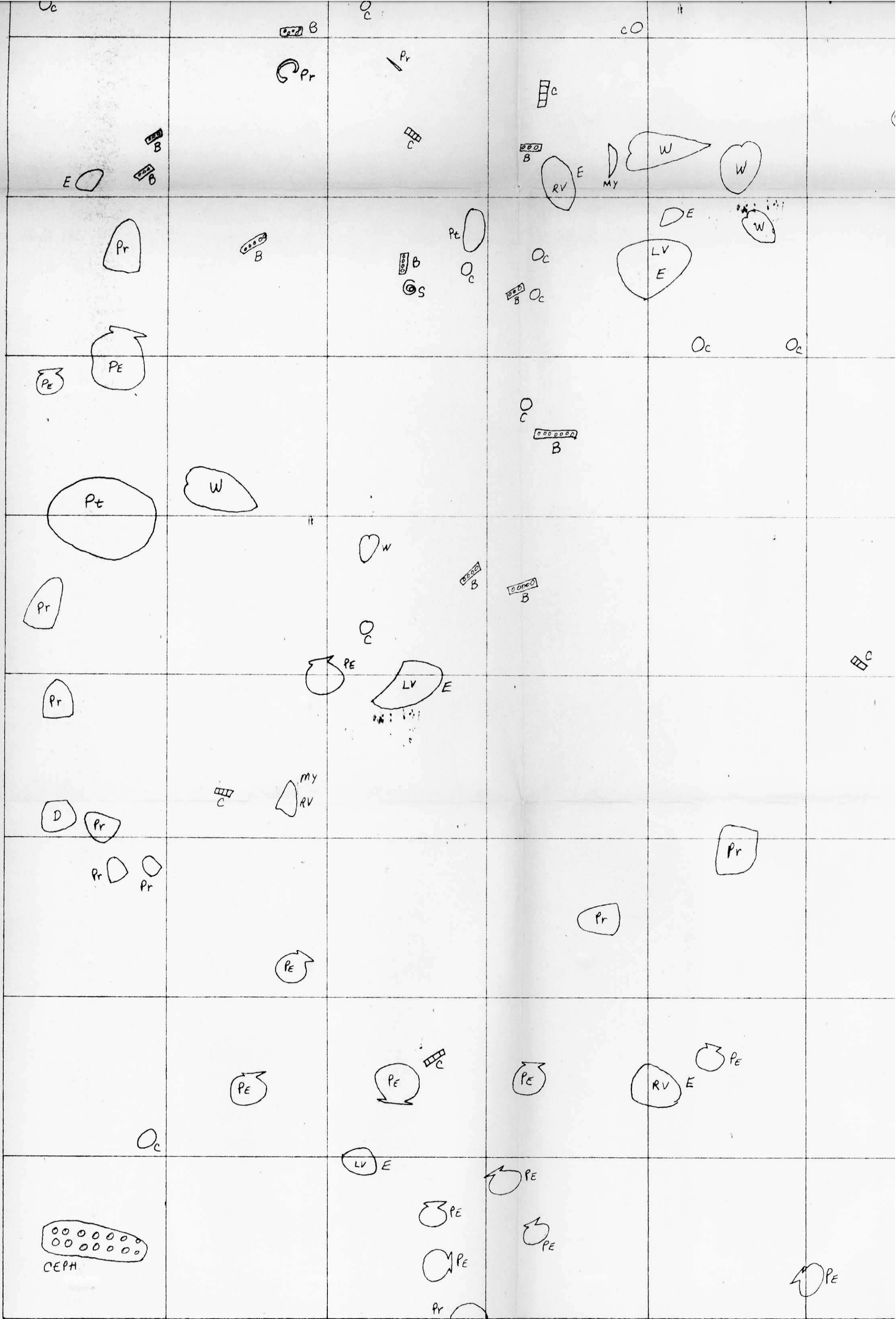


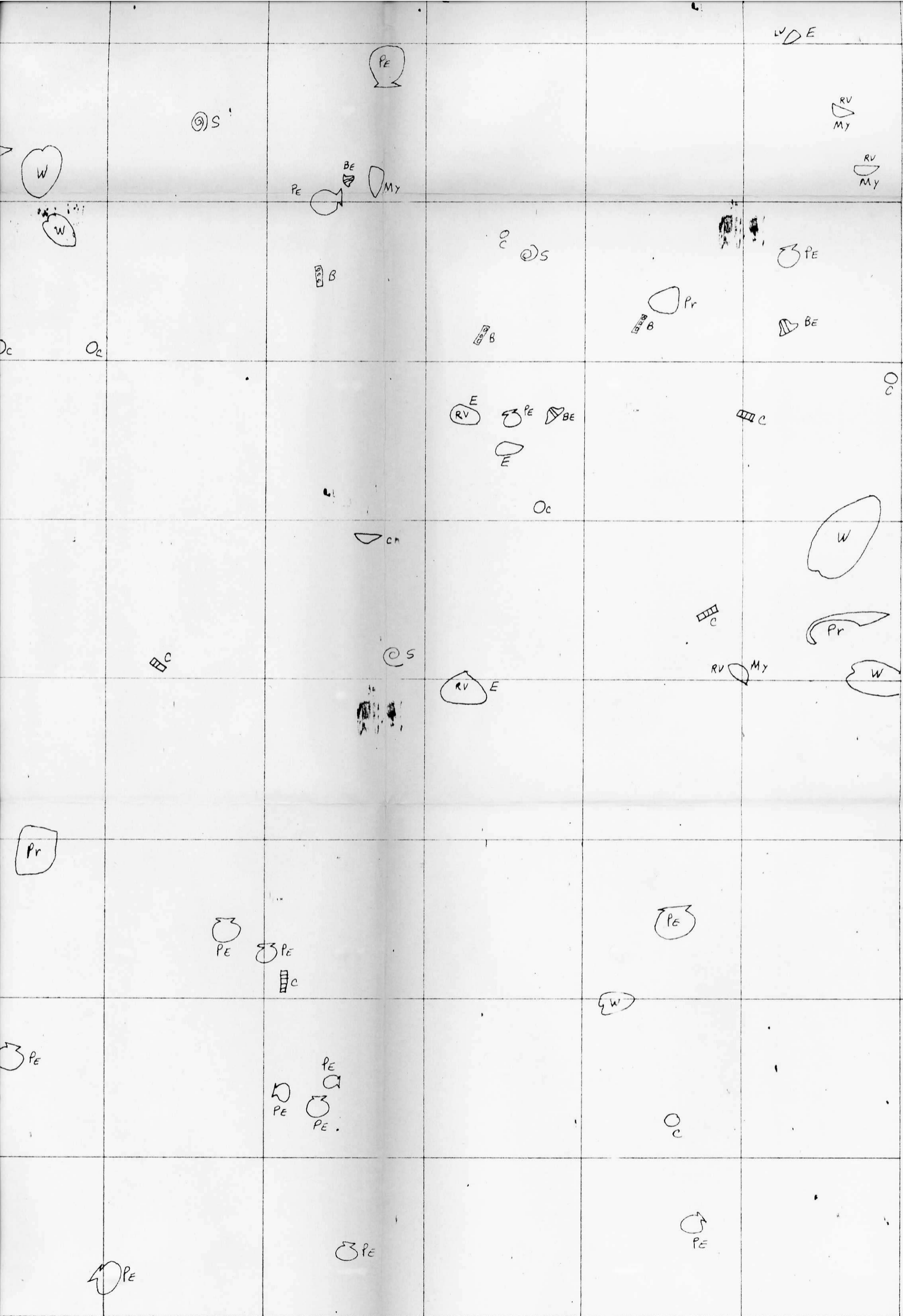
APPENDIX V

ORGANISMS IN A SQUARE METER OF HORIZON RdI

SCALE 2 INCHES = 1 DECIMETER



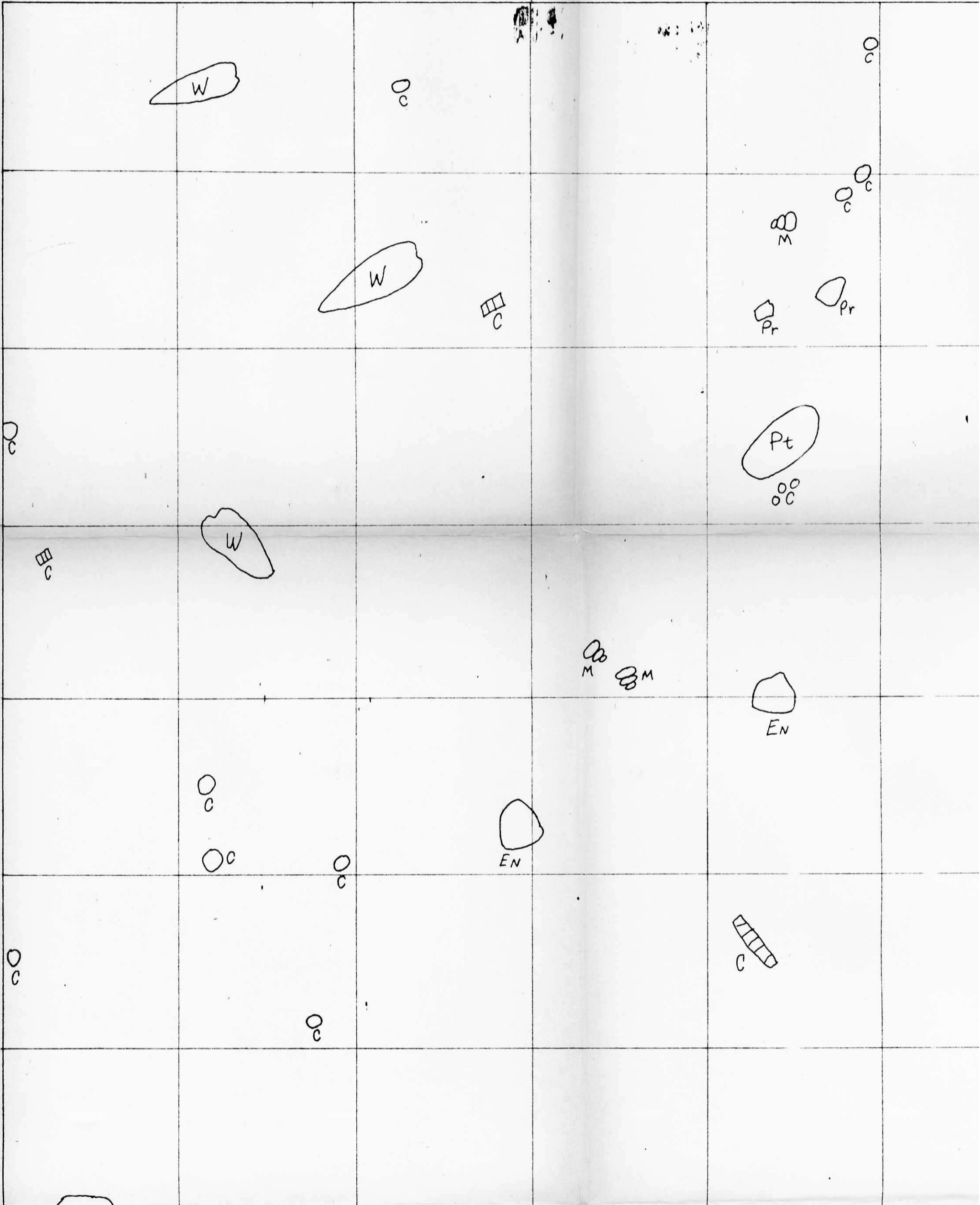




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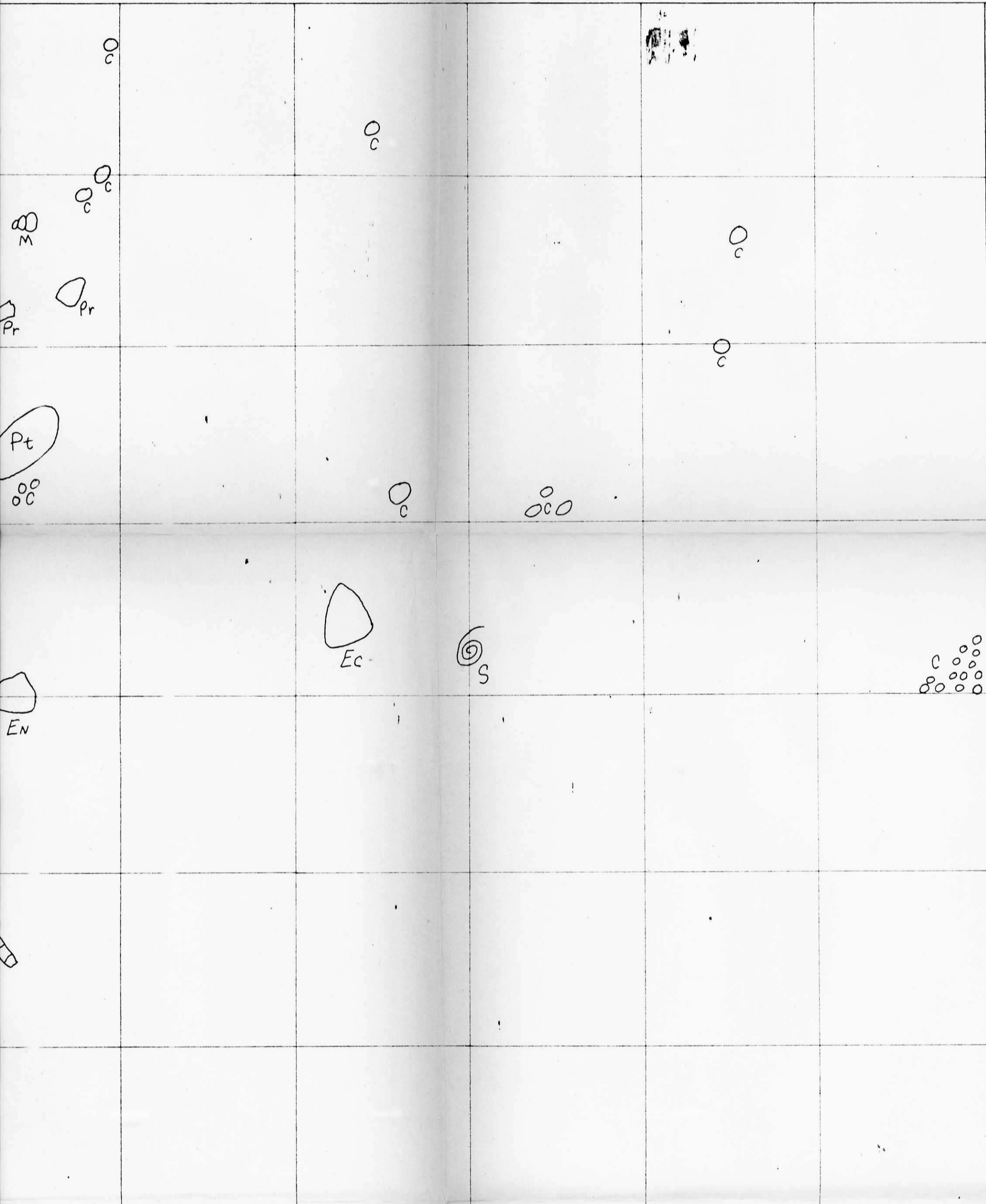
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APPENDIX VI

ORGANISMS IN A SQUARE METER OF HORIZON Rd2

1 INCH = 25.4 MILLIMETERS



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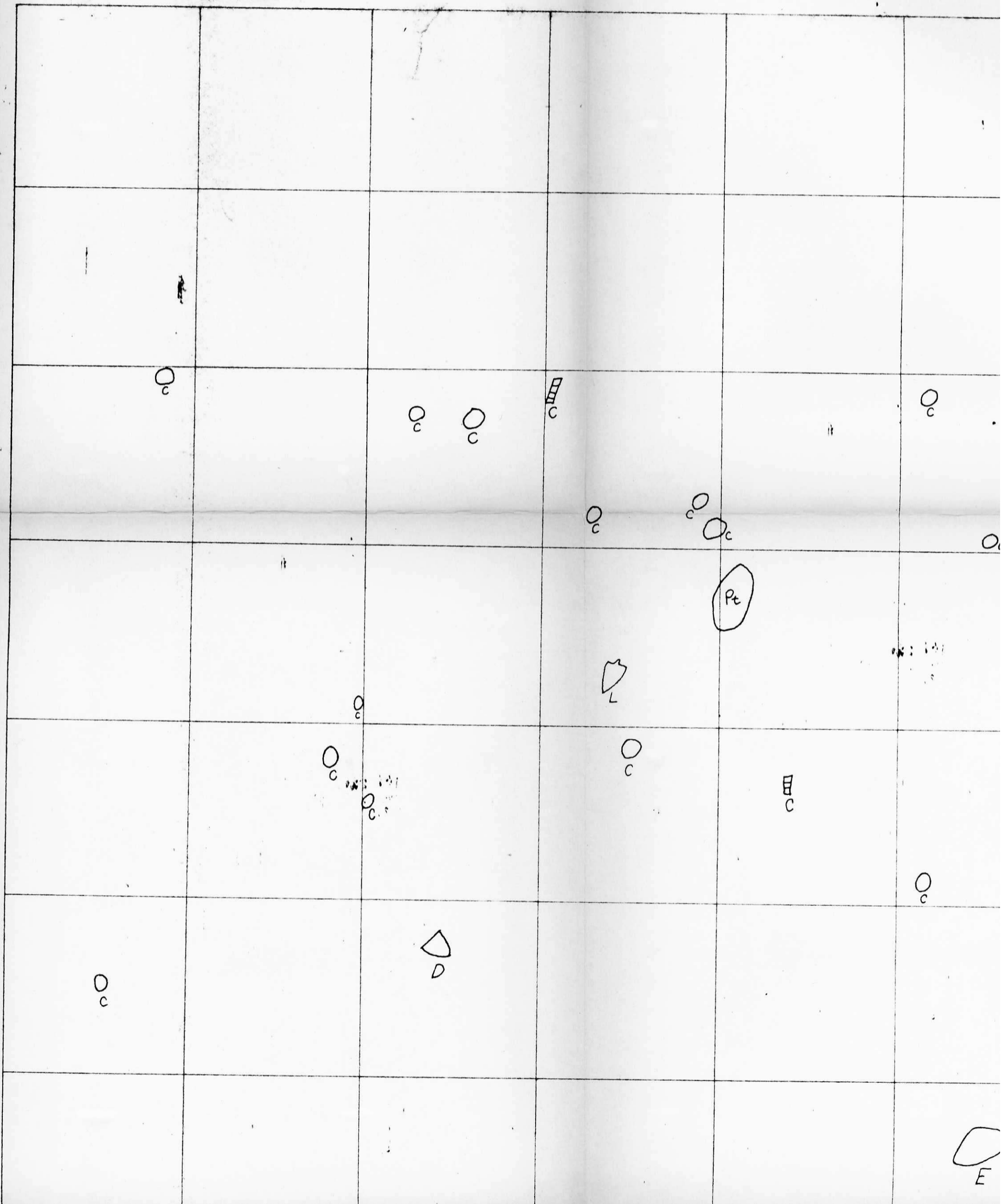
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SPATIAL DISTRIBUTION OF ORGANISMS IN A

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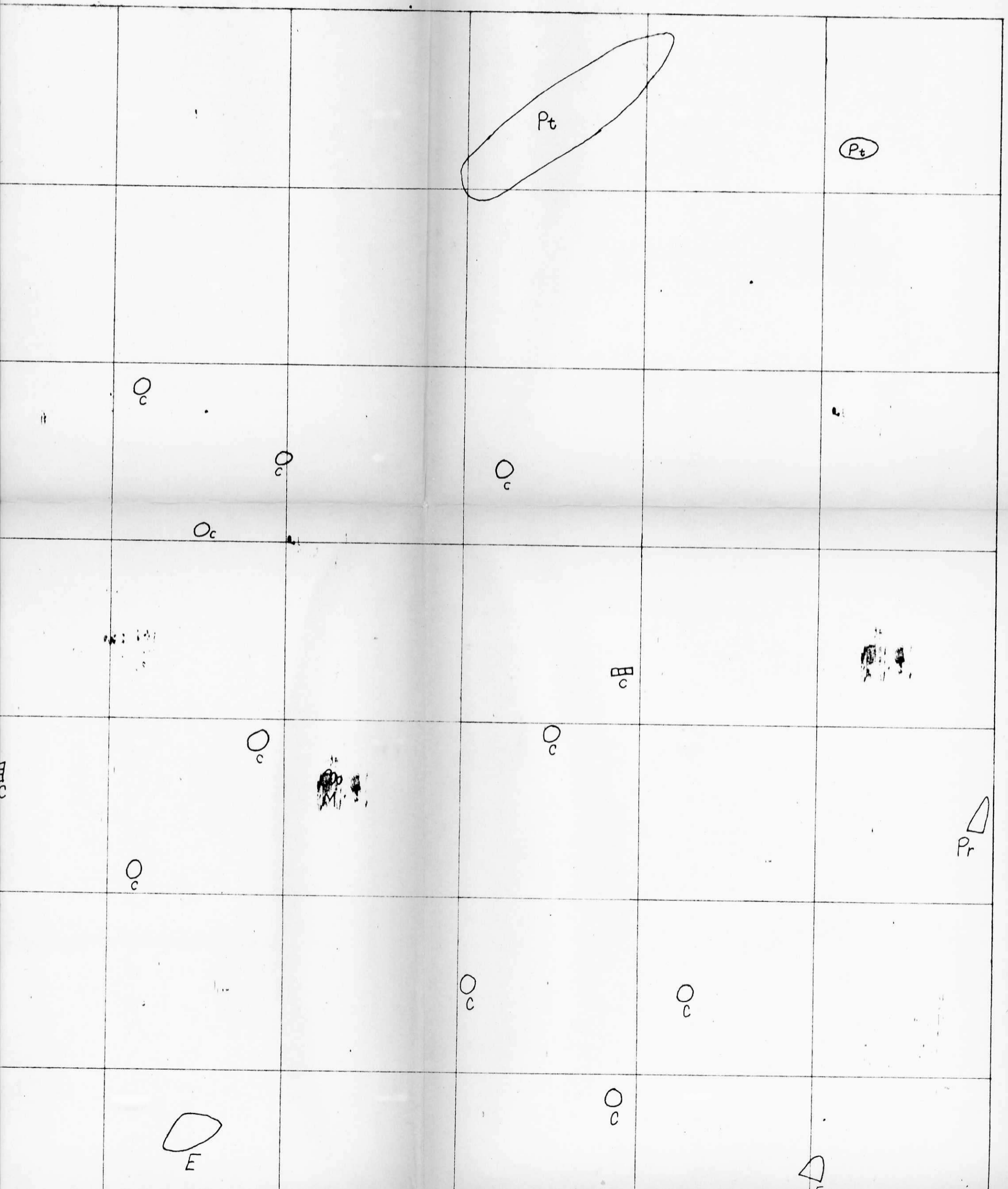
S42W

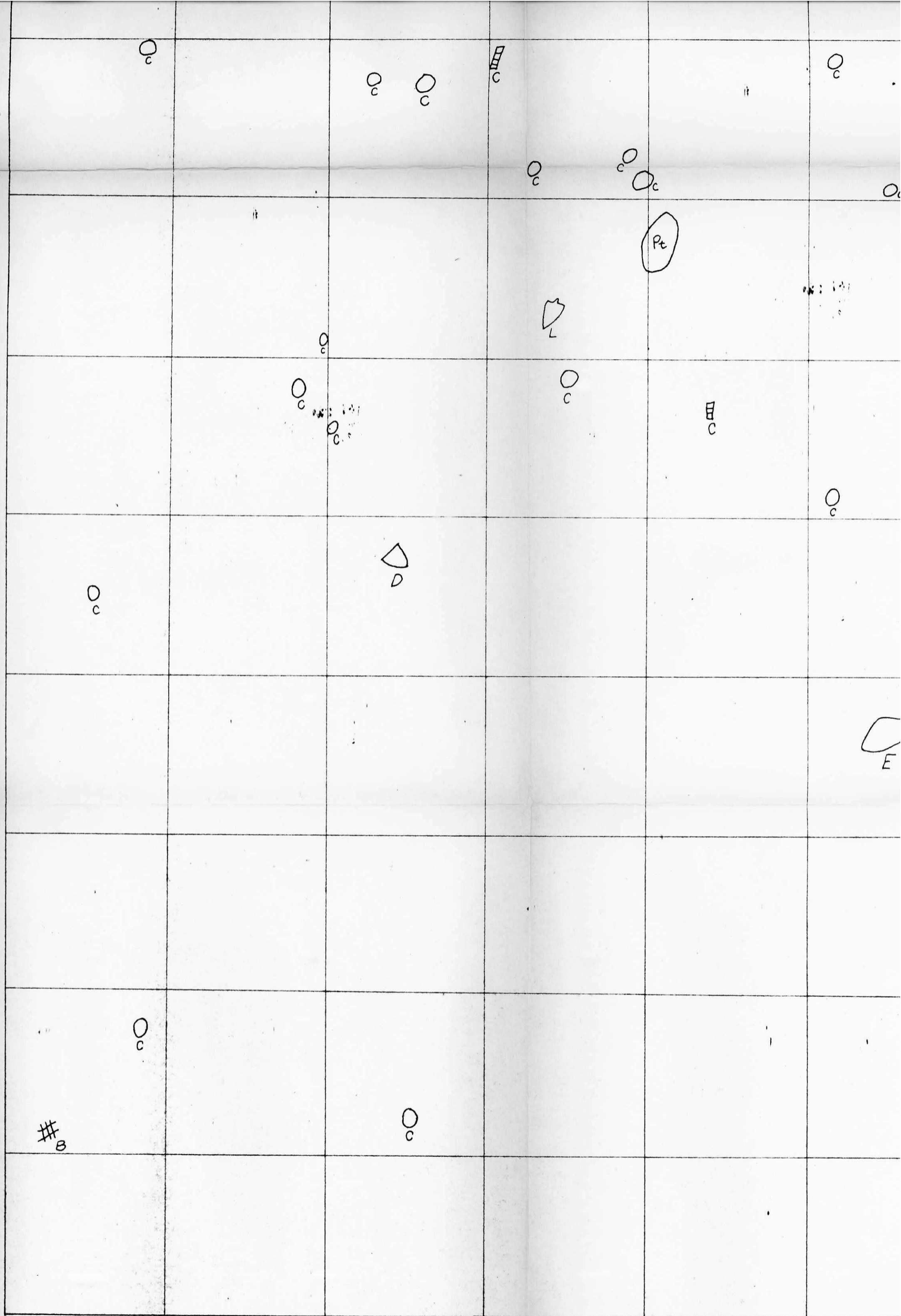


APPENDIX VII

ORGANISMS IN A SQUARE METER OF HORIZON Rd3

SCALE 2 INCHES = 1 DECIMETER





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A hand-drawn oval shape with a small lowercase letter 'c' written directly below it.

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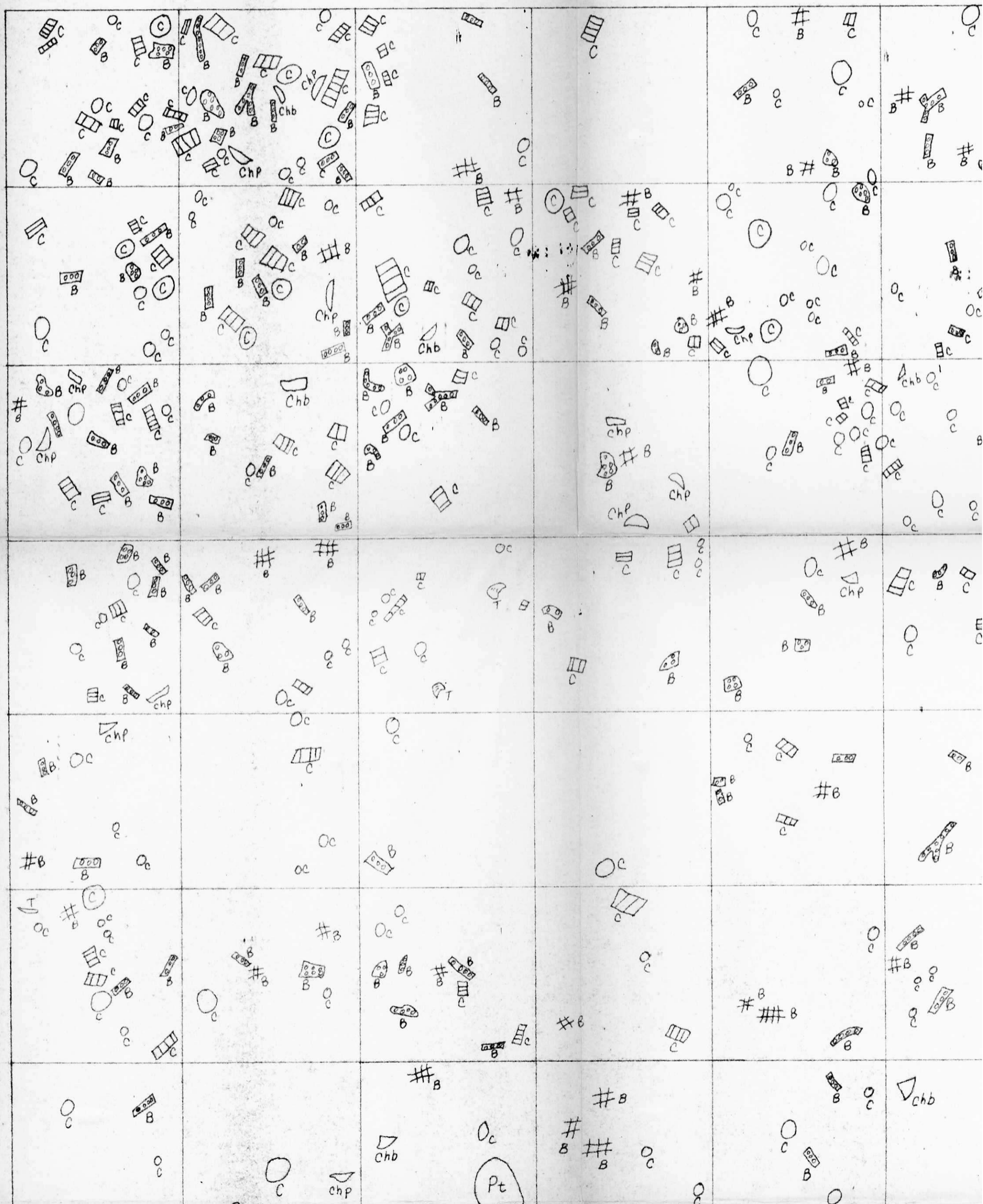
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SPATIAL DISTRIBUTION OF ORGANISMS IN A SC

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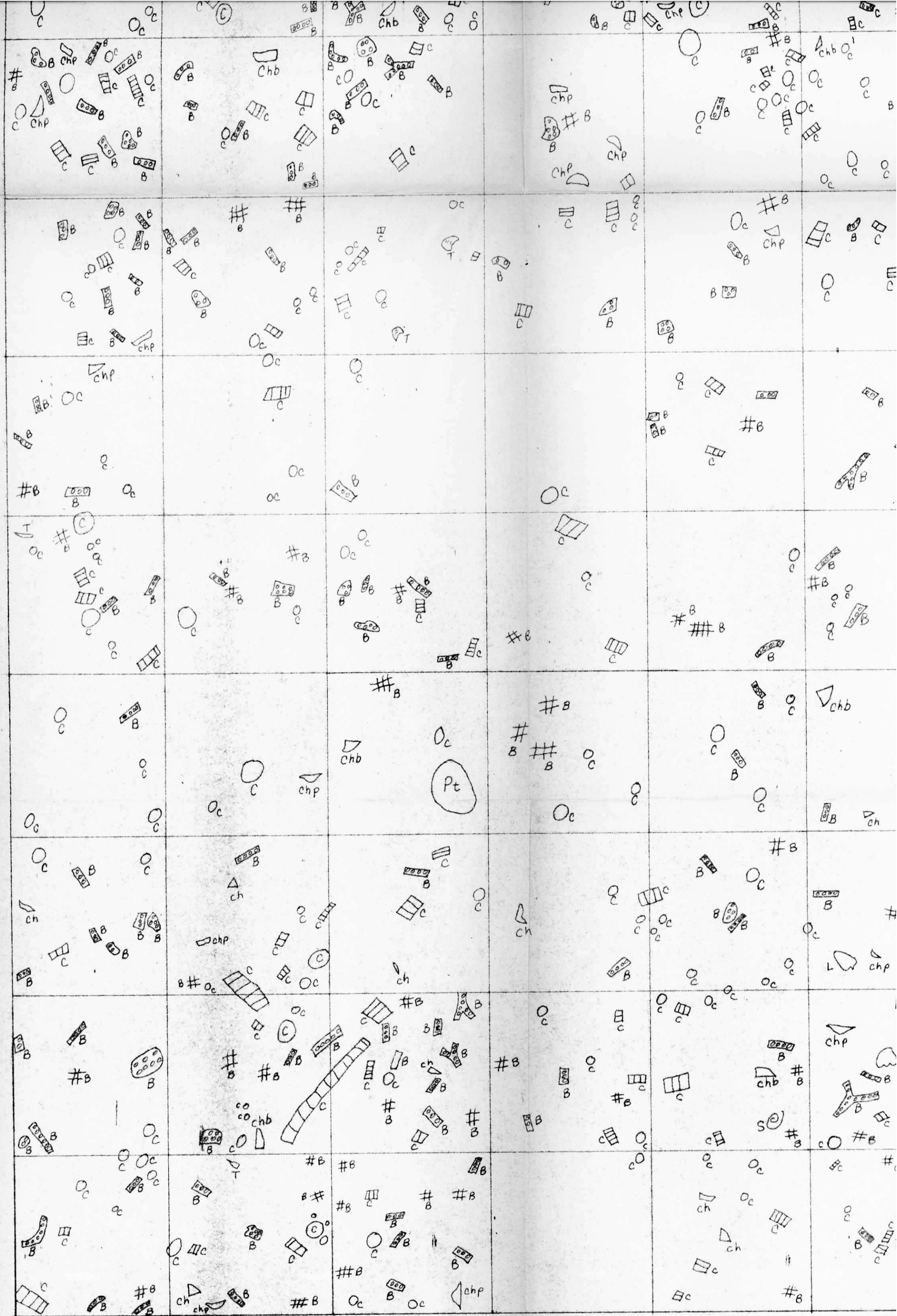


APPENDIX VIII

ORGANISMS IN A SQUARE METER OF HORIZON Rd4

LE 2 INCHES = 1 DECIMETER







END

OF

OVERSIZE

DOCUMENT(S)